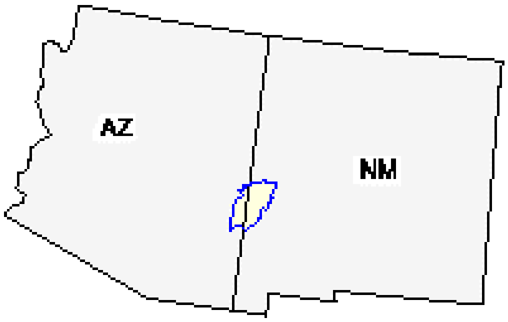
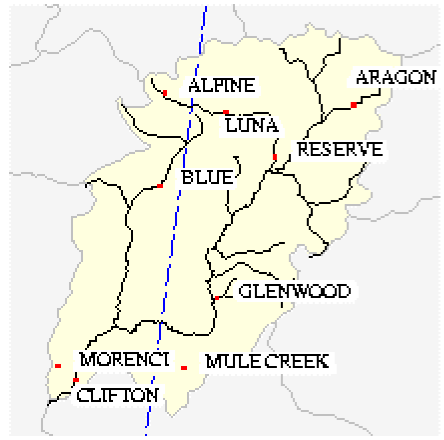
DRAFT

TOTAL MAXIMUM DAILY LOAD FOR PLANT NUTRIENTS ON MANGAS CREEK





Summary Table

New Mexico Standards Segment	Gila River Basin, 20.6.4.502, (formerly 2502)
Waterbody Identifier	Mangas Creek from the mouth on the Gila River to Mangas Springs, 4.7 mi
Parameters of Concern	Plant Nutrients
Uses Affected	Marginal Coldwater Fishery, Warmwater Fishery, Primary Contact Recreation
Geographic Location	Gila River Basin (GRB2-20100)
Scope/size of Watershed	204 mi^2 (Mangas Creek drainage area)
Land Type	Ecoregion: Arizona/New Mexico Mountains
Land Use/Cover	Rangeland (49%), Forest (47%), Barren (2%), Agricultural (1%), Water (1%)
Identified Sources	Natural, Rangeland, Hydromodification, Removal of Riparian Vegetation, Streambank Modification/Destabilization, Unknown
Watershed Ownership	Private (45%), Forest Service (40%), State (13%), Bureau of Land Management (2%)
Priority Ranking	8
Threatened and Endangered Species	None
TMDL for: Plant Nutrients (Algal Growth/Chlorophyll)	WLA + LA + MOS = TMDL **0 + 1.13 + 0.20 + = 1.33 lbs/day**

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List of Abbreviations

BLM	Bureau of Land Management
BMP	best management practice
CFS	cubic feet per second
CMS	cubic meters per second
CWA	Clean Water Act
CWAP	Clean Water Action Plan
CWF	Coldwater fishery
EDTA	ethylenediaminetetra-acetic acid
EPA	Environmental Protection Agency
FS	United States Forest Service
HQCWF	High quality coldwater fishery
LA	load allocation
MGD	million gallons per day
mg/L	milligrams per liter
MOS	margin of safety
MOU	memorandum of understanding
NMED	New Mexico Environment Department
NPDES	national pollution discharge elimination system
NPS	nonpoint sources
RBP	Rapid Bioassessment Protocol
SOP	Standard Operating Procedure
SWQB	Surface Water Quality Bureau
TMDL	total maximum daily load
UNM	University of New Mexico
USGS	United States Geological Survey
UWA	Unified Watershed Assessment
WLA	waste load allocation
WQLS	water quality limited segment
WQCC	New Mexico Water Quality Control Commission
WQS	water quality standards

EXECUTIVE SUMMARY

Section 303(d) of the federal Clean Water Act requires states to develop TMDL management plans for water bodies determined to be water quality limited. A TMDL documents the amount of a pollutant a water body can assimilate without violating a state's water quality standards. It also allocates that load capacity to known point sources and nonpoint sources at a given flow. TMDLs are defined in 40 CFR Part 130 as the sum of the individual Waste Load Allocations (WLA) for point sources and Load Allocations (LA) for nonpoint sources, including a margin of safety (MOS), and natural background conditions.

Looking upstream (SE) at lower Mangas Creek from Bill Evans Lake.

Mangas Creek surface water quality monitoring stations were used to characterize the water quality of Mangas Creek. As a result of this monitoring effort, several exceedances of New Mexico water quality standards for plant nutrients were documented on Mangas Creek from the mouth on the Gila River to Mangas Springs (GRB2-20100, 4.7 mi.). A nutrient assessment of Mangas Creek in 2001 determined the stream exhibited extensive filamentous algae growths leading to the impairment of the narrative standard for plant nutrients. A limiting nutrient and algal biomass for the creek determined moderately high productivity levels (Appendix E). This Total Maximum Daily Load (TMDL) document addresses plant nutrients. This reach has a priority 8 ranking.

Mangas Creek is in standards segment 20.6.4.502 NMAC (formerly 2502) of the Gila River Basin. Segment20.6.4.502 includes the mainstem of the Gila River from State Highway 464 in Redrock upstream to the Gila Hot Springs and perennial reaches of tributaries to the Gila River below the Town of Cliff. Designated uses include industrial water supply, irrigation, marginal coldwater fishery, livestock watering, wildlife habitat, warmwater fishery and primary contact. Uses not fully supporting due to excess plant nutrients (algal growth) are marginal coldwater fishery, warmwater fishery and primary contact.

A general implementation plan for activities to be established in the watershed is included in this document. The Surface Water Quality Bureau's Watershed Protection Section (SWQB/WPS) will further develop the details of this plan. Implementation of recommendations in this document will be done with full participation of all interested and affected parties. During implementation, additional water quality data may be generated.

As a result targets will be re-examined and potentially revised; this document is considered to be an evolving management plan. In the event that new data indicate that the targets used in this analysis are not appropriate or if new standards are adopted, the load capacity will be adjusted accordingly. When water quality standards have been achieved, the reach will be removed from the TMDL list.

Background Information

The perennial portion of Mangas Creek from the mouth on the Gila River to Mangas Springs is located in Southeastern New Mexico and is 4.7 miles in length. Mangas Creek, a tributary of the Gila River has a sub-watershed size of 204 mi^2. Land use/cover consists of 49% rangeland, 47% forest, 1% agricultural, 1% water, and 2% barren (Figure 1). The Forest Service (FS) has jurisdiction over 40% of this area while 45% is private, 13% is State, and 2% is Bureau of Land Management (BLM) owned (Figure 2).

Looking to the southeast at the Mangas Creek watershed above Mangas Springs from US Highway 180.

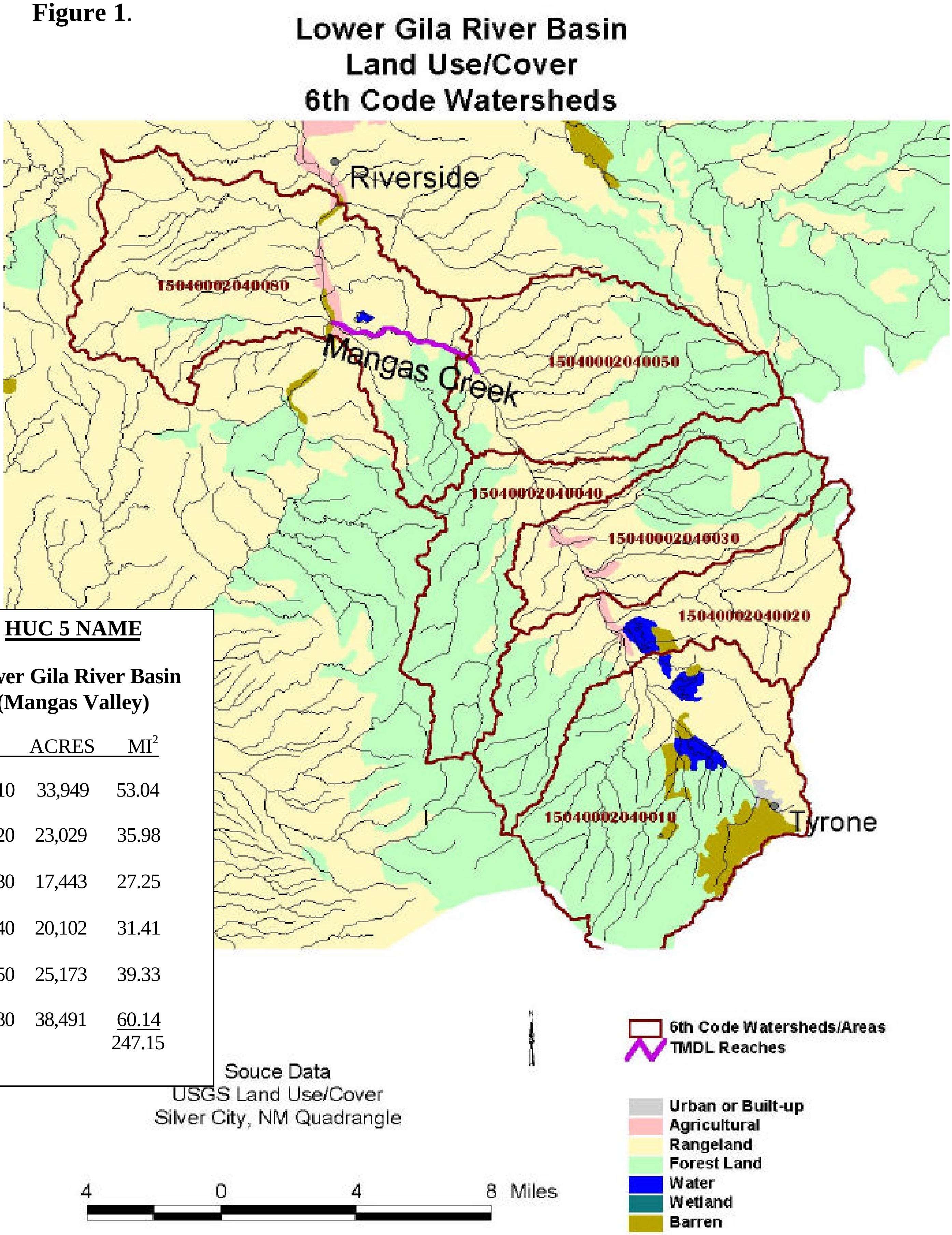
Surface water quality monitoring stations were used to characterize the water quality of the stream reaches. Stations were located to evaluate the impact on the stream and to establish background conditions. The result of the SWQB's monitoring effort demonstrates excessive nutrient enrichment in Mangas Creek and determined the need to write this TMDL.

Endpoint Identification

Target Loading Capacity

Overall, the target values are determined based on 1) the presence of numeric and narrative criteria, 2) the degree of experience in applying the indicator and 3) the ability to easily monitor and produce quantifiable and reproducible results. For this TMDL document the target value for plant nutrients is based on narrative and numeric criteria. This TMDL is consistent with the State antidegradation policy.

Figure 1.

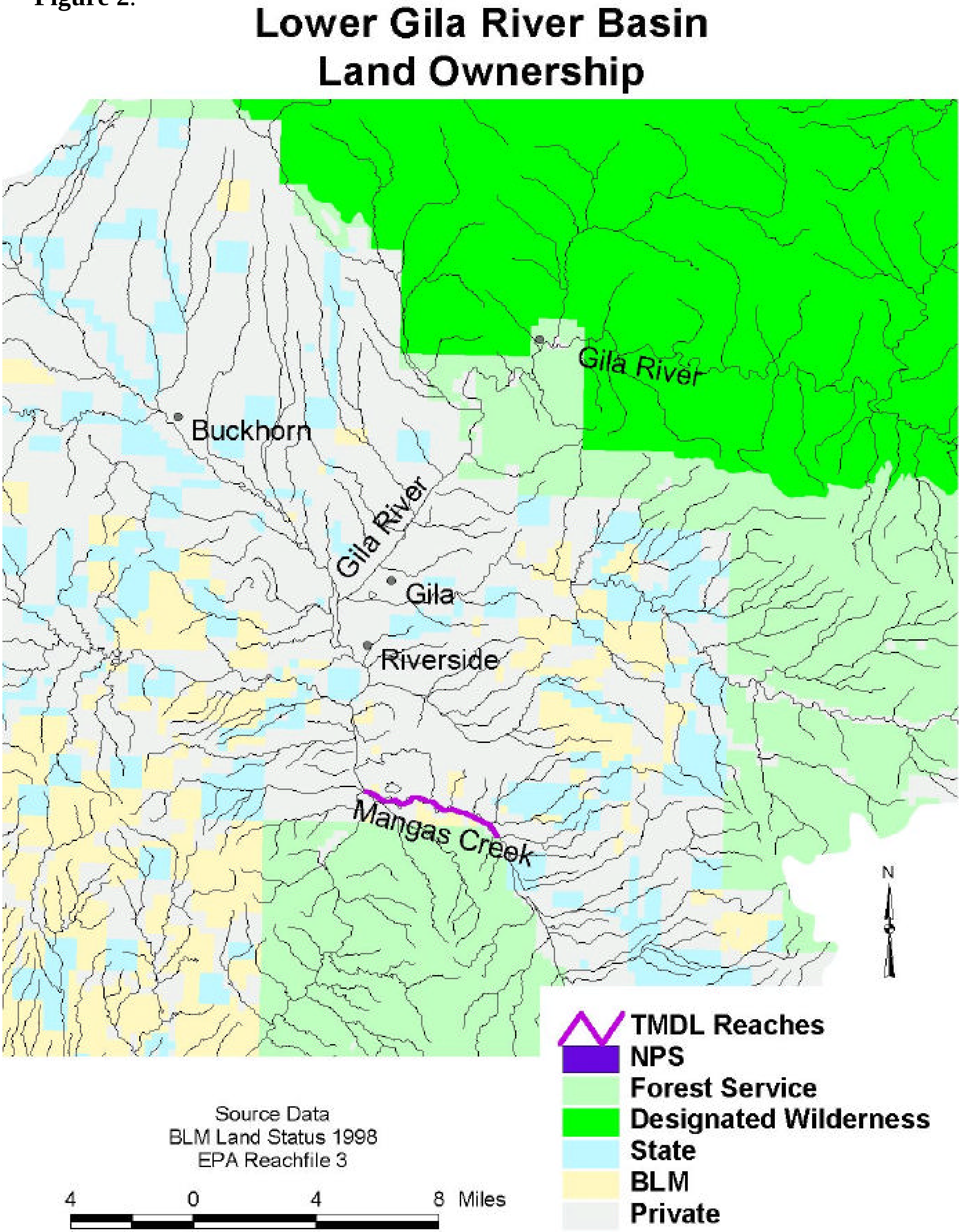


HUC 5 NAME

Lower Gila River Basin (Mangas Valley)

HUC	ACRES	MI^2
2040010	33,949	53.04
2040020	23,029	35.98
2040030	17,443	27.25
2040040	20,102	31.41
2040050	25,173	39.33
2040080	38,491	60.14
		247.15

Figure 2.



Lower Gila River Basin
Land Ownership
Gila River
Buckhorn
Gila River
Gila
Riverside
Mangas Creek
N
TMDL Reaches
NPS
Forest Service
Designated Wilderness
State
BLM
Private
Source Data
BLM Land Status 1998
EPA Reachfile 3
4 0 4 8 Miles

Plant Nutrients

The New Mexico Water Quality Control Commission (WQCC) has adopted narrative water quality standards for plant nutrients to sustain and protect existing or attainable uses of the surface waters of the State. This general standard applies to surface waters of the state at all times, unless a specified standard is provided elsewhere. The plant nutrient standard leading to an assessment of use impairment is as follows:

> *Plant nutrients from other than natural causes shall not be present in concentrations, which will produce undesirable aquatic life or result in the dominance of nuisance species in surface waters of the state.*

Mangas Creek is listed on the 2000-2002 NM 303(d) list of waters not meeting water quality standards, based on the presence of plant nutrients resulting in nuisance growths of algae. This reach was originally listed for plant nutrients based on 1992 data. This determination was based on the best professional judgment of the principal investigator during the 1992 intensive survey.

Plant Nutrient Assessment

View of the sonde at the lower Mangus Creek sampling station. Note the algal "mats" around the probe.

Since there are no numeric standards applicable to Mangas Creek for plant nutrients, an assessment for nutrient enrichment was made in the spring and summer 2001. This survey was conducted during high and low flow events in Mangas Creek. Additional water quality data were collected for nutrients, ions, and macroinvertebrates (using EPA's Rapid Bioassessment Protocols, RBP) and an algal bioassay was performed (Appendices D and E). As well, a data-collecting YSI® multi-parameter water analysis probe was deployed in Mangas Creek from May 3-10, 2001 and again from June 20-27, 2001 (Appendix B). This probe was programmed to record temperature, dissolved oxygen, conductivity, turbidity, and pH every hour over the period of deployment. This sonde data was used in the Nutrient Assessment Protocol to determine the elevated dissolved oxygen or pH reading which could indicate high levels of plant productivity in the stream. The sonde data results are discussed later in this document in the linkage of water quality and pollutant sources section.

Large diurnal fluctuations in dissolved oxygen or pH are indicative of nutrient enrichment in the stream. Algae reduce the levels of dissolved oxygen in the river during the early hours of the morning as a result of respiration. This reduction of dissolved oxygen can be a limiting factor for aquatic communities in Mangas Creek. The algae also increase dissolved oxygen above saturation during warm, sunny afternoons. These supersaturated levels could be harmful to fish in some instances causing gas-bubble disease in fish. Plants and algae also consume carbon dioxide which causes pH to rise. When algae and plants die, bacterial action promotes decay and nutrients are released either back into the water column or into the sediments. Nitrogen released during decomposition produces ammonia, and the amount of ammonia that is converted to the toxic unionized form is directly related to pH. Historic fisheries and aquatic macroinvertbrate data were also collected to determine the biotic health of Mangas Creek.

Algal Bioassay

There were no tests or models available to predict the combined effects of both macrophyte and algae interactions on nutrient cycles and water quality in Mangas Creek. Macrophytes compete with algae for light, so as their density and canopy height increases during the summer they inhibit algae growth. However, from the nutrient assessment on Mangas Creek there appeared to be more algae present in the stream than macrophyte growths (Appendix F). Therefore, an algal bioassay was performed for Mangas Creek. There are two potential contributors to nutrient enrichment, excessive nitrogen and phosphorus. In order to determine which of these two nutrients is limiting, an algal growth test was performed by the University of New Mexico (UNM) Department of Biology researchers (Appendix E). Laboratory analysis of ambient waters determined the water was not low in available nitrogen because with the addition of nitrogen, there is no increase in algal growth. The water is definitely low in phosphorus because with the addition of phosphorus there is nearly linear increase in algal growth. However, without added nutrients, water from Mangas Creek supported nearly four times the algal biomass compared to water from the San Francisco River and Centerfire Creek sites (Appendix E).

Looking upstream (east) at the 1999-2001 SWQB sampling station, "Mangus Creek above Gila". Note the sonde in the right center of the photo, overly abundant aquatic vegetation and lack of significant woody riparian vegetation.

Algal growth was measured by the UNM researchers by fluorescence measurements, and converted to algal dry weight by experimentally establishing a relationship between fluorescence and algal dry weight.

Various concentrations of N (as nitrate) and P (as phosphate), ethylenediaminetetra-acetic acid (EDTA), and iron (Fe as Fe III-EDTA) were added to the water samples from Mangas Creek along with *Selanastrum capricornutum* (Appendix E). Addition of EDTA did not stimulate growth, thereby indicating the absence of metal toxicity (Appendix E).

With respect to the plant nutrient problem in Mangas Creek, it becomes important to estimate the amount of nutrients that can be tolerated by Mangas Creek without presenting a plant nutrient problem. The algal bioassay for Mangas Creek provides a summary of algal growth in the bioassay when no additions of nutrients were made (Appendix E). This test determined that without any added nitrogen or phosphorus to the water sample, the algal biomass in Mangas Creek was already productive, indicating a current plant nutrient and algal growth problem. Nitrite and nitrate samples taken in Mangas Creek in March and June 2001 were elevated at 14.2 mg/L, 9.6 mg/L, and 14 mg/L (Appendix D). Total phosphorus values were quite low compared to nitrogen values. A specific numeric value which will indicate potential algal growths in Mangas Creek cannot be determined. There was already a significant algal growth problem occurring in Mangas Creek and it is not possible to back calculate to a level at which algal growth is not an issue.

Flow

The presence of plant nutrients in a stream can vary as a function of flow. As flow decreases, the concentration of plant nutrients can increase. Thus, a TMDL is calculated for each reach at a specific flow. The flow value used to calculate the TMDL for plant nutrients on Mangas Creek was obtained using a 4-day, 3-year low-flow frequency (4Q3) regression model (Appendix C). The 4Q3 is the annual lowest 4 consecutive day period discharge that will not fall below that discharge at least every 3 years (USGS, 2001). This method of estimating low flows was developed for ungaged, unregulated streams in New Mexico. Mangas Creek did not have a USGS gage on it. Low flow was chosen as the critical flow for Mangas Creek as there is more potential to have higher concentrations of plant nutrients in the stream during summer and early fall. Also, there is more potential to have higher water and air temperatures, decreased periods of scouring, and maximum solar gain.

It is important to remember that the TMDL is a planning tool to be used to achieve water quality standards. Since flows vary throughout the year in these systems the target load will vary based on the changing flow. Management of the load should set a goal at water quality standards attainment, not meeting the calculated target load.

Calculations

With respect to the plant nutrient problem in Mangas Creek, it was not possible to estimate the amount of nitrogen and phosphorus that can be tolerated by Mangas Creek without presenting a plant nutrient problem. Instead, the load calculations are based on algal growth. To address this, University of New Mexico (UNM) researchers relied on a 1978 EPA publication (Miller et al., 1978), which established four levels of productivity in surface waters. This publication is the most current paper known for productivity classification in surface waters based on algal bioassays.

Mangas Creek has current algal productivity values greater than the moderate productivity classification from Table 1 (Appendix E). The moderate productivity level for algal growth will be used in calculating the TMDL for plant nutrients. As stated previously, an excessive amount of aquatic vegetation is not beneficial to most stream life. The level of nutrient enrichment is often reflected by the types and amounts of aquatic vegetation in the water. High levels of nutrients may promote an overabundance of algae and floating and rooted macrophytes. Mangas Creek is already exhibiting moderately high productivity rates of algal growth.

Table 1: Productivity Classification Based on Algal Bioassays (Miller et al., 1978).

Algal Growth (mg dry weight/L)	Classification
0.00-0.10	Low productivity
0.11-0.80	**Moderate productivity**
0.81-6.00	Moderately high productivity
6.10-20.00	High productivity

This TMDL was developed based on simple dilution calculations using 4Q3 flow and the EPA moderate level productivity criterion based on algal bioassays in mg dry weight (Table 1). The TMDL calculation includes wasteload allocations, load allocations, and a margin of safety.

Target loads for plant nutrients are calculated based on a low flow (4Q3), the average value of the moderate productivity algal plant growth (Table 1) (0.455 mg dry weight/L), and a unit-less conversion factor of 8.34, that is used to convert mg/L units to lbs/day (Appendix A Conversion Factor Derivation). The target loading capacity is calculated using Equation 1.

Equation 1. critical flow (mgd) x moderate level productivity criterion (mg dry weight/L) x 8.34 (conversion factor)= target loading capacity

The target loads (TMDLs) predicted to attain standards were calculated using Equation 1 and are shown in Table 2.

Table 2: Calculation of Target Loads

Location	Flow* (mgd)	Moderate Level Productivity Criterion** (mg dry weight/L)	Conversion Factor	Target Load Capacity (lbs/day)
Mangas	0.35	0.455	8.34	1.33

*Flow obtained using the 4Q3 regression model (USGS 2001) (Appendix C)
**From Table 1.Productivity Classification Based on Algal Bioassays (Miller et al., 1978)

The measured loads were calculated using Equation 1. The flows were derived based on the 4Q3 for Mangas Creek. The productivity of algae in Mangas Creek when no additions of nitrogen or phosphorus were made in the bioassay are used in the calculation of the measured loads (Appendix E). Thus, the 1.9 mg dry weight/L from Mangas Creek is substituted for the moderate productivity criterion from Table 1 to calculate the measured load (Table 3).

This is the direct measurement from the stream water. This calculation is based on the chlorophyll content and fluorescence measurements. The same conversion factor of 8.34 was used. Results are presented in Table 3.

Background loads were not possible to calculate in this sub-watershed. A reference reach, having similar stream channel morphology and flow, was not found. It is assumed that a portion of the load allocation is made up of natural background loads. In future water quality surveys, finding a suitable reference reach will be a priority.

Table 3: Calculation of Measured Loads

Location	**Flow* (mgd)**	**LabMeasure** Algal Growth (mg dry weight/L)**	**Conversion Factor**	**Measured Load (lbs/day)**
Mangas	0.35	1.9	8.34	5.55

*Flow obtained using the 4Q3 regression model (USGS 2001) (Appendix C)
**The actual lab measure for algal growth in Mangas Creek (in mg dry weight/L).

Waste Load Allocations and Load Allocations

Waste Load Allocation

There are no point source contributions associated with this TMDL. The waste load allocation is zero.

Load Allocation

In order to calculate the Load Allocation (LA), the waste load allocation, background, and margin of safety (MOS) were subtracted from the target capacity (TMDL) following Equation 2.

Equation 2. $WLA + LA + MOS = TMDL$

Results are presented in Table 4 (Calculation of TMDL for Plant Nutrients mg dry weight/L).

Table 4: Calculation of TMDL for Plant Nutrients (mg dry weight/L).

Location	**WLA (lbs/day)**	**LA (lbs/day)**	**MOS (15%) (lbs/day)**	**TMDL (lbs/day)**
Mangas Creek	0	1.13	0.20	1.33

The load reductions that would be necessary to meet the target loads were calculated to be the difference between the target load (Table 1) and the measured load (Table 2), and are shown in Table 4 (Calculation of Load Reductions).

Table 5: Calculation of Load Reductions (lbs/day)

Location	Target Load	Measured Load	Load Reductions
Mangas Creek	1.33	5.55	4.22

Identification and Description of Pollutant Source(s)

Table 6: Pollutant Source Summary

Pollutant Sources (% from each)	**Magnitude** (WLA + LA + MOS)	**Location**	**Potential Sources**
Point: None	0	--------	None
Nonpoint: (100%) Plant Nutrients		Mangas Creek	Natural, Rangeland, Removal of Riparian Vegetation, Streambank Destabilization, Hydromodification

Linkage of Water Quality and Pollutant Sources

Where available data are incomplete or where the level of uncertainty in the characterization of sources is large, the recommended approach to TMDLs requires the development of allocations based on estimates utilizing the best available information. SWQB fieldwork includes an assessment of the potential sources of impairment (SWQB/NMED 2000a) and the Nutrient Assessment Protocol (Appendix F).

These protocols established by the SWQB include the Pollutant Source(s) Documentation Protocol (Appendix G), and the Nutrient Assessment Protocol (Appendix F).

To determine whether a reach is nutrient impaired and large enough to cause undesirable water quality changes, three levels of assessment are available in the Nutrient Assessment Protocol (Appendix F). Level one and two nutrient assessments were used on Mangas Creek in 2001.

To provide more information for the Nutrient Assessment Protocol, SWQB staff collected additional water quality data from Mangas Creek May 3-10, 2001 and June 20-27, 2001. These water quality surveys were done during high and low flows. Macroinvertebrates using EPAs RBP had previously been collected in 2001 by SWQB staff. Mangas Creek was sampled in 2001 and compared against two different reference sites (Whitewater Creek at the Catwalk, and Negrito Creek above the Tularosa River).

Results showed Mangas Creek as being in full support, impacts observed (FSIO) against both sites. The biological condition, using Negrito Creek as a reference, showed that Mangas Creek is slightly impaired (FSIO), with 59% of the reference condition present. Using Whitewater Creek as a reference, Mangas Creek had 64% of the reference condition. The Hilsenhoff Biotic Index (HBI) measures overall pollution tolerance of the benthic community to the degree of organic pollution. Mangas Creek had a score of 6.13 which indicated fairly significant organic pollution in the stream.

Recent fish data (1999) taken by the Phelps Dodge Corporation and shared with the SWQB by the Gila National Forest indicate Mangas Creek is a very productive stream with Longfin dace (*Agrosia chrysogaster*), Desert Sucker (*Catostomus Clarkii)*, Loach Minnow *(Tiaroga Cobitis)*, and Speckled dace *(Meda Fulgida)*. Speckled dace inhabit shallow, rocky stream areas with aquatic vegetation, but has a low tolerance to reduced oxygen levels. Breeding fish need to clear gravels in the stream of periphyton and debris to build nests. Longfin dace, during low water levels can take refuge in moist detritus and algal mats in streams, and is somewhat tolerant to reduced oxygen levels. Desert Suckers are bottom dwelling species that have a low tolerance to reduced oxygen levels in streams. Loach Minnow shows a definite preference for cobble/gravel substrate and it is restricted to gravelly riffles, often in association with beds of filamentous algae.

Samples for nutrients and major ions were also collected for the nutrient assessment. Water samples for the limiting nutrient and algal bioassay were also collected on June 20, 2001. Results indicated that nitrogen levels were extremely elevated (Appendix D).

Overall, the observational and quantitative data collected for the nutrient assessment (Level 1 and 2) for Mangas Creek showed a violation of the narrative standard for plant nutrients, and indicated a water quality impairment. There were extensive amounts of dead filamentous algae on either side of the stream, which indicated there had been a large scouring event in the stream. Visual observation by the Silver City SWQB staff, prior to June sampling, confirmed that the creek had been full of dense mats of filamentous algae. This dieoff was most likely a result of drought conditions versus a scouring or flood event. Also, there did not appear to be a riparian corridor to decrease the amount of incident sunlight to the stream or to stabilize the streambanks (Appendix F). Several data points for pH and DO from the sondes deployed in May 2001 indicate possible high plant productivity in the stream. Afternoon DO levels were greater than 11mg/L and pH values were greater than 8.5. Both elevated values support impairment (Appendix B).

The Pollutant Source(s) Documentation Protocol, shown as Appendix G, provides an approach for a visual analysis of a pollutant source along an impaired reach. Although this procedure is subjective, SWQB feels that it provides the best available information for the identification of potential sources of impairment in this watershed.

Table 6 (Pollutant Source Summary) identifies and quantifies potential sources of nonpoint source impairments along each reach as determined by field reconnaissance and assessment. A further explanation of the sources follows.

Mangas Creek

The primary sources of impairment along this reach are natural, hydromodification, removal of riparian vegetation, rangeland, streambank destabilization/modification and unknown. Erosive soils and poor watershed condition are common throughout the Mangas Creek watershed. Significant watershed damage occurred in this area around the turn of the century. Erosion is attributed to both natural causes and land uses. Dense thickets of trees have grown over the past century as a result of fire suppression. The historic grasslands and savannah types are presently being converted to piñon and juniper woodlands. The herbaceous plant community, that once bound the soil together with fine roots, slowed the runoff rate and provided channels for water to penetrate the soil. This has been drastically reduced.

Historical grazing practices have also had a significant impact in the Mangas Creek watershed. Overstocking of livestock was a common practice continuing until after the First World War. Beginning as early as the 1920s cattle numbers began to decline and today a combination of management practices, fencing and water development, as well as dramatically reduced cattle numbers considerably reduces the impact cattle have on the watershed. Cattle in the riparian area of Mangas Creek may represent an important source of nutrient contributions. Animal waste in the stream or riparian area can directly impair water quality by increasing nutrient levels.

The perennial portion of Mangas Creek flows from Mangas Springs, which are located on private land. According to correspondence with the Gila National Forest and New Mexico Environment Department staff in 2001, a significant amount of the high nutrient levels recorded in this reach may be naturally occurring and attributable to its groundwater source. Mangas Springs (a natural source of nutrients) are located down gradient of the Phelps Dodge Corporation Tyrone Mine. Ongoing monitoring of certain wells surrounding the mine tailings piles by Phelps Dodge, demonstrates somewhat high levels of NO_3-N specifically in samples from wells 14 and 10. However, some may also be attributable to excessive runoff, considering the condition of the watershed, as well as the historical grazing practices. A Mangas Water Quality Project Work Plan was formed in 2001 to remediate any anthropogenic sources of this nutrient enrichment problem and restore the integrity of the watershed. This will be discussed later in the document.

Margin of Safety (MOS)

TMDLs should reflect a margin of safety based on the uncertainty or variability in the data, the point and nonpoint source load estimates, and the modeling analysis. For this TMDL, there will be no margin of safety for point sources, since there are none. However, for the nonpoint sources the margin of safety for plant nutrients is estimated to be an addition of **15%** of the TMDL, excluding the background. This margin of safety incorporates several factors:

•*Errors in calculating NPS loads*

A level of uncertainty exists in sampling nonpoint sources of pollution. Techniques used for measuring plant nutrient concentrations (phosphorus and nitrogen) in stream water have a (±)10% precision (SWQB/NMED, 1999b). Accordingly, a conservative margin of safety increases the TMDL by **10%**.

•*Errors in calculating flow*

Flow estimates were based on the estimation of the 4Q3 for ungaged streams. Techniques used for measuring the flow on Mangas Creek have a (±) 5% precision. Accordingly, a conservative margin of safety increases the TMDL by **5%**.

Consideration of Seasonal Variability

Data used in the calculation of this TMDL were collected during high and low flow seasons in order to ensure coverage of any potential seasonal variation in the system. A data-collecting YSI® multi-parameter water analysis probe was deployed in Mangas Creek May 3-10, 2001, and June 20-27, 2001 (Appendix B).

Future Growth

Estimations of future growth are not anticipated to lead to a significant increase for plant nutrients that cannot be controlled with best management practice implementation in this watershed.

Monitoring Plan

Pursuant to Section 106(e)(1) of the Federal Clean Water Act, the SWQB has established appropriate monitoring methods, systems and procedures in order to compile and analyze data on the quality of the surface waters of New Mexico.

In accordance with the New Mexico Water Quality Act, the SWQB has developed and implemented a comprehensive water quality monitoring strategy for the surface waters of the State. The monitoring strategy establishes the methods of identifying and prioritizing water quality data needs, specifies procedures for acquiring and managing water quality data, and describes how these data are used to progress toward three basic monitoring objectives: to develop water quality-based controls, to evaluate the effectiveness of such controls and to conduct water quality assessments.

The SWQB utilizes a rotating basin system approach to water quality monitoring. In this system, a select number of watersheds are intensively monitored each year with an established return frequency of every five years.

The SWQB maintains current quality assurance and quality control plans to cover all monitoring activities. This document, “Quality Assurance Project Plan for Water Quality Management Programs” (QAPP) is updated annually.

Current priorities for monitoring in the SWQB are driven by the 303(d) list of streams requiring TMDLs. Short-term efforts will be directed toward those waters which are on the EPA TMDL consent decree (Forest Guardians and Southwest Environmental Center v. Carol Browner, Administrator, US EPA, Civil Action 96-0826 LH/LFG, 1997) list and which are due within the first two years of the monitoring schedule. Once assessment monitoring is completed those reaches showing impacts and requiring a TMDL will be targeted for more intensive monitoring.

The methods of data acquisition include fixed-station monitoring, intensive surveys of priority waterbodies, including biological assessments, and compliance monitoring of industrial, federal and municipal dischargers, and are specified in the SWQB Assessment Protocol (SWQB/NMED 2000c).
Long term monitoring for assessments will be accomplished through the establishment of sampling sites that are representative of the water body and which can be revisited every five years. This gives an unbiased assessment of the waterbody and establishes a long term monitoring record for simple trend analyses. This information will provide time relevant information for use in 305(b) assessments and to support the need for developing TMDLs.

The approach provides:

- A systematic, detailed review of water quality data, allowing for a more efficient use of valuable monitoring resources.
- Information at a scale where implementation of corrective activities is feasible.
- An established order of rotation and predictable sampling in each basin, which allows forehanded coordinated efforts with other programs.
- Program efficiency and improvements in the basis for management decisions.

It should be noted that a basin would not be ignored during its four-year sampling hiatus. The rotating basin program will be supplemented with other data collection efforts.

Data will be analyzed, field studies will be conducted, to further characterize identified problems, and TMDLs will be developed and implement. Both long term and field studies can contribute to the 305(b) report and 303(d) listing processes.

The following schedule is a draft for the sampling seasons through 2002 and will be followed in a consistent manner to support the New Mexico Unified Watershed Assessment (UWA) and the Nonpoint Source Management Program. This sampling regime allows characterization of seasonal variation and through sampling in spring, summer, and fall for each of the watersheds.

- 1998 Jemez Watershed, Upper Chama Watershed (above El Vado), Cimarron Watershed, Santa Fe River, San Francisco Watershed
- 1999 Lower Chama Watershed, Red River Watershed, Middle Rio Grande, Gila River Watershed (summer and fall), Santa Fe River
- 2000 Gila River Watershed (spring), Dry Cimarron Watershed, Upper Rio Grande 1 (Pilar north to the NM/CO border), Shumway Arroyo
- 2001 Upper Rio Grande 2 (Pilar south to Cochiti Reservoir), Upper Pecos Watershed (Ft Sumner north to the headwaters

- 2002 Lower Pecos Watershed (Roswell south to the NM/TX border including Ruidoso), Canadian River Watershed, Lower Rio Grande (southern border of Isleta Pueblo south to the NM/TX border), San Juan River Watershed, Rio Puerco Watershed, Closed Basins, Zuni Watershed, Mimbres Watershed

Implementation Plan

Management Measures

Management measures are "economically achievable measures for the control of the addition of pollutants from existing and new categories and classes of nonpoint sources of pollution, which reflect the greatest degree of pollutant reduction achievable through the application of the best available nonpoint pollution control practices, technologies, processes, citing criteria, operating methods, or other alternatives"(USEPA, 1993). A combination of best management practices (BMPs) and public education will be used to implement this TMDL.

Introduction

The presence of some aquatic vegetation is normal in streams. Algae and macrophytes provide habitat and food for all stream animals. However, an excessive amount of aquatic vegetation is not beneficial to most stream life. The level of nutrient enrichment is often reflected by the types and amounts of aquatic vegetation in the water. High levels of nutrients (especially nitrogen and phosphorus) may promote an overabundance of algae and floating and rooted macrophytes.

Plant respiration and decomposition of dead vegetation consume dissolved oxygen in the water. Lack of dissolved oxygen creates stress for all aquatic organisms and can cause fish kills. A landowner may have seen fish gulping for air at the water surface during warm weather, indicating a lack of dissolved oxygen (DO). Increases in primary productivity can increase invertebrates and fish in streams. However, excessive plant growth and decomposition can limit aquatic populations by decreasing dissolved oxygen concentrations. Nocturnal respiration can cause oxygen depletion in waters with high primary productivity and low aeration rates.

Reduced base flow, either naturally occurring (drought) or through anthropogenic actions, will also result in higher temperatures, slower water movement, and therefore, show increased nutrient levels.

The following is a list of examples that can contribute to plant nutrient exceedances:

- Point source nutrient contributions can come from wastewater ineffectively treated.
- Nonpoint sources of nutrients can be related to agricultural activities, such as over-application of fertilizer on fields or animal waste runoff including confined animal operations and grazing activities.
- Storm water runoff in urban areas can include fertilizer from lawns and pet waste.

- Septic tanks, cesspools, or any other mechanism for removal of liquid waste from human habitation are large contributors to surface water nutrients when ground water is shallow or systems have been improperly installed.
- Recreational areas such as horse trails or heavily used fishing areas, where the riparian vegetation has been removed or reduced, can contribute nutrients if waste materials run off into the stream. By removing riparian areas, the filtering mechanism for the runoff is also removed.
- Removal of water, through diversion, can reduce base stream flow and may possibly contribute high plant nutrient levels when temperatures rise. For example, stagnant pools can form in streams during extremely low flows and have excessive amounts of aquatic vegetation.

Actions to be Taken

For this watershed the primary focus will be on the control of plant nutrients.

During the TMDL process in this watershed, point sources have been reviewed and will be addressed through the permit process. The nonpoint source contributions will need to address nutrient exceedances through BMP implementation.

Various BMPs can be used to address plant nutrient exceedances. Examples include:

1. A filter strip or vegetated buffer. These BMPs are particularly advantageous for runoff from agricultural fields and storm water drains because the vegetation would absorb a percentage of the nutrients. This BMP would also prevent sediment loading and turbidity in the river system by providing a filtering process for the runoff (US EPA.1993. <u>Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters</u>.).

2. Detention basins are effective techniques for the control of pollutant discharges from storm water runoff and confined animal operations. The basins would isolate potentially polluted runoff from streams (<u>Urban Targeting and BMP Selection</u>, 1990, US EPA.).

3. Following source control management. Reduced and efficient application of fertilizer on agricultural fields, lawns, golf courses can effectively prevent nutrient loading in runoff (<u>New Mexico Farm-A-Syst Farmstead Assessment System</u>, 1992, New Mexico State University, College of Agriculture and Home Economics, Cooperative Extension Service, Plant Sciences Department.).

4. Maintaining a healthy riparian ecosystem. The riparian functions to filter sediments from runoff will take up nutrients through root systems and provides shade to reduce ambient sunlight, which also increases aquatic growth (<u>Revegetating Southwest Riparian Areas</u>, New Mexico State University, College of Agriculture and Home Economics, Cooperative Extension Service.).

Additional sources of information for BMPs to address conductivity are listed below. Some of these documents are available for viewing at the New Mexico Environment Department, Surface Water Quality Bureau, Watershed Protection Section Library, 1190 St. Francis Drive, Santa Fe, New Mexico.

Agriculture

Internet websites:

http://www.nm.nrcs.usda.gov/

http://www.nhq.nrcs.usda.gov/land/env/wq7.html

http://www.agcom.purdue.edu/AgCom/news/backgrd/9804.Joern.phosphorus.html

http://www.umaine.edu/pswl/Nutrient Management.htm

http://www.ag.ohio-state.edu/~ohioline/aex-fact/0464.html

- Bureau of Land Management, 1990, Cows, Creeks, and Cooperation: Three Colorado Success Stories. Colorado State Office.

- Cotton, Scott E. and Ann C. Cotton, Wyoming CRM: Enhancing our Environment.

- Goodloe, Sid, Watershed Restoration through Integrated Resource Management on Public and Private Rangelands.

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- Maas, Richard P., Steven A. Dressing, and others, Best Management Practices for Agricultural Nonpoint Source Control, IV. Pesticides. USDA/EPA joint project Rural Nonpoint Source Control Water Quality Evaluation and Technical Assistance.

- New Mexico State University, 1992, New Mexico Farm-A-Syst Farmstead Assessment System. College of Agriculture and Home Economics, Cooperative Extension Service, Plant Sciences Department.

  Section 6, Improving household Wastewater Management
  Section 7, Improving Livestock Waste Storage
  Section 8, Improving Livestock Yards Management

- USEPA Region 6 and Terrene Institute, 1994, Pollution Control for Horse Stables and Backyard Livestock, (handout).

- USEPA Region 4 and Tennessee Valley Authority, Animal Waste Treatment by Constructed Wetlands, (pamphlet).

- USEPA, Animal Waste Treatment by Constructed Wetlands. Water Management Division, Region 5, (pamphlet).

Urban/Storm Water

- Delaware Department of Natural Resources and Environmental Control, 1997, Conservation Design for Stormwater Management: A Design Approach to Reduce Stormwater Impacts from Land Development and Achieve Multiple Objectives Related to Land Use. Sediment and Stormwater Program & the Environment Management Center, Brandywine Conservancy.

- US EPA, 1990, Urban Targeting and BMP Selection. Region V, Water Division.

- Taylor, Scott and G. Fred Lee, 2000, Stormwater Runoff Water Quality. Science/Engineering Newsletter, Urban Stormwater Runoff Water Quality Management Issues, Vol. 3, No. 2. May 19.

Miscellaneous

Internet website:

http://water.usgs.gov/nawqa/nutrient.html

- International Erosion Control Association, 1994, Sustaining Environmental Quality: The Erosion Control Challenge, Proceedings of Conference XXV, February.

- New Mexico Environment Department, 2000, A Guide to Successful Watershed Health. Surface Water Quality Bureau.

- New Mexico Environment Department, Maintaining your Septic System, (pamphlet).

- Terrene Institute, 1991, Your Guide to Preventing Water Pollution.

- USDA Forest Service Southwestern Region, Soil and Water Conservation Practices Handbook.

  1.)Section 22 – Range Management 22-1 through 22-4.
  2.)Section 23 – Recreation 23-2, 23-3, 23-5, & 23-6.

- USEPA, 1992, Managing Nonpoint Source Pollution. Office of Water, EPA-506/9-90.

- USEPA Region 6 and Terrene Institute, 1994, Landscape Design and Maintenance for Pollution Control, (handout).

- USEPA Region 4, 1992. A Common Sense Guide to Rural Environmental Protection.
- USEPA, 1999, Protocol for Developing Nutrient TMDLs. 1st Edition, EPA841-B-99-007.

  1.) Table 2. Common BMPs employed to control nutrient transport from agricultural and urban nonpoint sources, pg. 2-13.
  2.) Nutrient Controls, pg.2-12

- USEPA, 1993, Guidance Specifying Management Measures For Sources of Nonpoint Pollution in Coastal Waters. Office of Water, Coastal Zone Act Reauthorization Amendments of 1990 (Authority of §6217(g)), EPA840-B-92-002.

- USEPA, 1999, Protocol for Developing Nutrient TMDLs. Office of Water, 4503 F, Washington DC 20460, EPA841-B-99-007, November, 1st Edition.

- USEPA Region 4, 1992. A Common Sense Guide to Rural Environmental Protection, 345 Courtland Street, N.E., Atlanta, Georgia, 30365, EPA904-B-92-002, September.

- Unknown, Selecting BMPs and other Pollution Control Measures.

- Unknown, Environmental Management. Best Management Practices

  Construction Sites
  Developed Areas
  Sand and Gravel Pits
  Farms, Golf Courses, and Lawns

- Zeedyk, William D., Managing Roads for Wet Meadow Ecosystem Recovery, USDA-FS, Southwestern Region, Report # FHWA-FLP-96-016

Other BMP activities in the Watershed

The following are activities in this watershed that have occurred, are occurring, or are in the planning stages to address plant nutrient sources or other nonpoint source issues impacting Mangas Creek.

Fire suppression and overgrazing have contributed to the degradation in the Mangas Creek watershed. The Mangas Water Quality Project, which will be administered and conducted primarily by the Grant Soil & Water Conservation District and the Silver City District of the Gila National Forest, will return fire to the ecosystem of the Burro Mountains. As a result, over time, the tree and shrub component of the plant community will be reduced, herbaceous vegetation will increase, and sheet type erosion will be reduced. Six areas are identified to stop gully and head-cut erosion. This project will be conducted preliminary to the construction of erosion control structures planned for the deeply incised channel of Mangas Creek.

Sediments in Mangas Creek and the Gila River originate from sheet erosion as well as head-cutting of water channels. Reducing over-story and revitalizing the herbaceous plant community will reduce sheet erosion. According to the Natural Resources Conservation Service, the current rate of soil erosion within the Mangas watershed on 12% slopes, is 1.11 tons per acre per year. Five years treatment, erosion rates on 12% slopes are expected to be 0.75 tons per acre per year. Current erosion rate on 25% slopes is about 2.39 tons per acre per year. Five years after treatment, erosion is expected to be 1.61 tons per acre per year.

During March and April of 2001 a burn was conducted on the Northwest end of the Mangas Creek watershed. This burn involved approximately 5,000 acres and was conducted by the Forest Service. This burn is to enhance watershed health and improve Mule Deer habitat. It is the intention of the Mangas Water Quality Project to continue the work described above throughout the Mangas Creek watershed.

The Mangas Water Quality Project will also complete an ongoing private streambank stabilization project. A private landowner has planted several hundred cottonwood and black willow trees to stabilize about one half mile of the Mangas Creek streambank. Approximately one quarter of a mile of the project remains along one side of the creek. This Mangas Water Quality Project will obtain approximately 300 trees from the New Mexico plant materials farm at Los Lunas NM. These trees will be 12 ft. bare poles. They will be placed in holes drilled into the muddy stream bank using a tractor-mounted posthole auger.

Coordination

In the Mangas Creek watershed, public awareness and involvement will be crucial to the successful implementation of this plan and improved water quality. Staff from the SWQB will work with stakeholders to provide the guidance in developing the Watershed Restoration Action Strategy (WRAS). The WRAS is a written plan intended to provide a long-range vision for various activities and management of resources in a watershed. It includes opportunities for private landowners and public agencies in reducing and preventing impacts to water quality. This long-range strategy will become instrumental in coordinating and achieving a reduction of plant nutrient levels and will be used to prevent water quality impacts in the watershed. SWQB staff will assist with any technical assistance such as selection and application of BMPs needed to meet WRAS goals.

Stakeholder public outreach and involvement in the implementation of this TMDL will be ongoing. Stakeholders in this process will include SWQB, and other partners of the Watershed Restoration Action Strategy.

Implementation of BMPs within the watershed to reduce pollutant loading from nonpoint sources will be on a voluntary basis. Reductions from point sources will be addressed in revisions to discharge permits.

Timeline

Implementation Actions	Year 1	Year 2	Year 3	Year 4	Year 5
Public Outreach and Involvement	X	X	X	X	X
Establish Milestones	X				
Secure Funding	X		X		
Implement Management Measures (BMPs)		X	X		
Monitor BMPs		X	X	X	
Determine BMP Effectiveness				X	X
Re-evaluate Milestones				X	X

Section 319(h) Funding Options

The Watershed Protection Section of the SWQB provides USEPA §319(h) funding to assist in implementation of BMPs to address water quality problems on reaches listed on the §303(d) list or which are located within Category I Watersheds as identified under the Unified Watershed Assessment of the Clean Water Action Plan. These monies are available to all private, for profit and nonprofit organizations that are authenticated legal entities, or governmental jurisdictions including: cities, counties, tribal entities, Federal agencies, or agencies of the State. Proposals are submitted by applicants through a Request for Proposal (RFP) process and require a non-federal match of 40% of the total project cost consisting of funds and/or in-kind services. Further information on funding from the Clean Water Act § 319 (h) can be found at the New Mexico Environment Department website: http://www.nmenv.state.nm.us/swqb/wpstop.html.

Assurances

New Mexico's Water Quality Act (Act) does authorize the Water Quality Control Commission to "promulgate and publish regulations to prevent or abate water pollution in the state" and to require permits. The Act authorizes a constituent agency to take enforcement action against any person who violates a water quality standard. Several statutory provisions on nuisance law could also be applied to nonpoint source water pollution. The Water Quality Act also states in § 74-6-12(a):

> *The Water Quality Act (this article) does not grant to the commission or to any other entity the power to take away or modify the property rights in water, nor is it the intention of the Water Quality Act to take away or modify such rights.*

In addition, the State of New Mexico Surface Water Quality Standards (Sections 20.6.4.6 C and 20.6.4.10.C NMAC) states:

> *These water quality standards do not grant to the Commission or any other entity the*

power to create, take away or modify property rights in water.

New Mexico policies are in accordance with the federal Clean Water Act §101(g):

It is the policy of Congress that the authority of each State to allocate quantities of water within its jurisdiction shall not be superseded, abrogated or otherwise impaired by this Act. It is the further policy of Congress that nothing in this Act shall be construed to supersede or abrogate rights to quantities of water which have been established by any State.

Federal agencies shall co-operate with State and local agencies to develop comprehensive solutions to prevent, reduce and eliminate pollution in concert with programs for managing water resources.

New Mexico's Clean Water Action Plan has been developed in a coordinated manner with the State's 303(d) process. All Category I watersheds identified in New Mexico's Unified Watershed Assessment process are totally coincident with the impaired waters lists for 1996 and 1998 as approved by EPA. The State has given a high priority for funding, assessment, and restoration activities to these watersheds.

The description of legal authorities for regulatory controls/management measures in New Mexico's Water Quality Act does not contain enforceable prohibitions directly applicable to nonpoint sources of pollution. The Act does authorize the Water Quality Control Commission to "promulgate and publish regulations to prevent or abate water pollution in the state" and to require permits. Several statutory provisions on nuisance law could also be applied to nonpoint source water pollution. NMED nonpoint source water quality management utilizes a voluntary approach. The State provides technical support and grant monies for implementation of BMPs and other NPS prevention mechanisms through § 319 of the Clean Water Act. Since portions of this TMDL will be implemented through NPS control mechanisms, the New Mexico Watershed Protection Program will target efforts to this and other watersheds with TMDLs. The Watershed Protection Program coordinates with the Nonpoint Source Taskforce. The Nonpoint Source Taskforce is the New Mexico statewide focus group representing Federal and State agencies, local governments, tribes and pueblos, soil and water conservation districts, environmental organizations, industry, and the public.

This group meets on a quarterly basis to provide input on the § 319 program process, to disseminate information to other stakeholders and the public regarding nonpoint source issues, to identify complementary programs and sources of funding, and to help review and rank § 319 proposals.

In order to obtain reasonable assurances for implementation in watersheds with multiple landowners, including Federal, State and private land, NMED has established Memoranda of Understanding (MOUs) with various Federal agencies, in particular the Forest Service and the Bureau of Land Management. MOUs have also been developed with other State agencies, such as the New Mexico State Highway and Transportation Department. These MOUs provide for coordination and consistency in dealing with nonpoint source issues.

Milestones

Milestones will be used to determine if control actions are being implemented and standards attained. For this TMDL, several milestones will be established which will vary and will be determined by the BMPs implemented. Examples of milestones for plant nutrients include:

- percentage reductions in sources of nitrogen and phosphorus contributions,
- increase in the miles of vegetative buffers between agricultural activities and roads, and the stream, and
- percentage of restored riparian buffers in the watershed.

Milestones will be coordinated by SWQB staff and will be re-evaluated periodically, depending on which BMPs were implemented. Further implementation of this TMDL will be revised based on this reevaluation. As additional information becomes available during the implementation of the TMDL, the targets, load capacity, and allocations may need to be changed. In the event that new data or information show that changes are warranted, TMDL revisions will be made with assistance of interested stakeholders. The re-examination process will involve: monitoring pollutant loading, tracking implementation and effectiveness of controls, assessing water quality trends in the waterbody, and re-evaluating the TMDL for attainment of water quality standards. Although specific targets and allocations are identified in the TMDL, the ultimate success of the TMDL is not whether these targets and allocations are met, but whether beneficial uses and water quality standards are achieved.

Measures of Success

- Improved bank stability and vegetation stability by increasing root systems thus decreasing sediment inputs into the system and improving canopy densities. Measurement tools include but are not limited to canopy densities and root density estimates.

- Increased interagency cooperation via communications with the land management agencies, soliciting their input into the process.

- Increased public participation via pre-monitoring and post-monitoring meetings.

- Increased interagency agreement in determining BMP application and suitability.

- Appropriateness of milestones will be re-evaluated periodically, depending on the BMPs that were implemented. Further implementation of this TMDL will be revised based on this re-evaluation.

Public Participation

Public participation was solicited in development of this TMDL. See Appendix H for flow chart of the public participation process. The draft TMDL was made available for a 30-day comment period starting **October 9, 2001**. Response to comments is attached as Appendix I of this document. The draft document notice of availability was extensively advertised via newsletters, email distribution lists, web page postings (http://www.nmenv.state.nm.us/public_notice.htm) and press releases to area newspapers.

References Cited

Forest Guardians and Southwest Environmental Center v. Carol Browner, Administrator, US EPA, Civil Action 96-0826 LH/LFG, 1997.

Miller, W.E. J.C. Greene and T. Shiroyama 1978. The *Slenastrum capricornutum* Printz Algal Assay Bottle Test. Corvallis Environmental Research Laboratory, U.S. Environmental Protection Agency Corvallus, OR. EPA-600/9-78-018

SWQB/NMED. 2000a. Pollutant Source Documentation Protocol.

SWQB/NMED. 2001b. Quality Assurance Project Plan. Rev No.6

SWQB/NMED. 2000c. State of New Mexico Procedures for Assessing Standards Attainment for 303(d) List and 305(b) Report Assessment Protocol.

SWQB/NMEDd. 2000. Nutrient Assessment Protocol For Streams.

USEPA. 1993. Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters. EPA-840-B-92-002. Washington, D.C.

USGS. 2001. Analysis of the Magnitude and Frequency of the 4-day, 3-Year Annual Low-Flow and Two Regional Regression Models for Ungaged Sites on Unregulated Streams in New Mexico. USGS Water-Resources Investigations Report 01.

Appendices

Appendix A: Conversion Factor Derivation

8.34 Conversion Factor Derivation

Million gallons/day **x** Milligrams/liter **x** 8.34 = pounds/day

10^6~~gallons~~/day **x** 3.7854 liters/~~1 gallon~~ **x** 10^{-3}gram/liter **x** 1 pound/454 ~~grams~~ = pounds/day

10^6 (10^{-3}) (3.7854)/454 = 3785.4/454

= 8.3379
= **8.34**

Appendix B: Sonde Data (as part of the Nutrient Assessment DO and pH Protocol)

DateTime M/D/Y	DO Conc mg/L	pH	DateTime M/D/Y	DO Conc mg/L	pH
05/03/2001 9:00	13.4	8.11	05/04/2001 23:00	10.2	8.02
05/03/2001 10:00	13.36	8.4	05/05/2001 0:00	10.43	8.03
05/03/2001 11:00	13.32	8.43	05/05/2001 1:00	10.68	8.05
05/03/2001 12:00	13.11	8.46	05/05/2001 2:00	10.87	8.06
05/03/2001 13:00	12.83	8.54	05/05/2001 3:00	11.05	8.07
05/03/2001 14:00	12.49	8.52	05/05/2001 4:00	11.22	8.07
05/03/2001 15:00	12.23	8.49	05/05/2001 5:00	11.39	8.08
05/03/2001 16:00	11.95	8.42	05/05/2001 6:00	11.54	8.08
05/03/2001 17:00	11.53	8.33	05/05/2001 7:00	11.99	8.11
05/03/2001 18:00	10.99	8.24	05/05/2001 8:00	13.04	8.2
05/03/2001 19:00	10.43	8.18	05/05/2001 9:00	13.61	8.28
05/03/2001 20:00	9.43	8.07	05/05/2001 10:00	13.76	8.42
05/03/2001 21:00	8.99	7.95	05/05/2001 11:00	13.54	8.52
05/03/2001 22:00	9.17	7.94	05/05/2001 12:00	13.44	8.57
05/03/2001 23:00	9.38	7.95	05/05/2001 13:00	13.25	8.55
05/04/2001 0:00	9.55	7.96	05/05/2001 14:00	12.94	8.57
05/04/2001 1:00	9.75	7.98	05/05/2001 15:00	12.68	8.53
05/04/2001 2:00	9.87	7.98	05/05/2001 16:00	12.43	8.47
05/04/2001 3:00	10.01	7.98	05/05/2001 17:00	12.1	8.38
05/04/2001 4:00	10.14	7.98	05/05/2001 18:00	11.62	8.29
05/04/2001 5:00	10.33	8	05/05/2001 19:00	10.8	8.27
05/04/2001 6:00	10.54	8.02	05/05/2001 20:00	9.93	8.05
05/04/2001 7:00	11.05	8.06	05/05/2001 21:00	9.74	7.97
05/04/2001 8:00	12.27	8.18	05/05/2001 22:00	9.94	7.98
05/04/2001 9:00	12.98	8.28	05/05/2001 23:00	10.12	8.01
05/04/2001 10:00	13.27	8.39	05/06/2001 0:00	10.39	8.03
05/04/2001 11:00	13.35	8.5	05/06/2001 1:00	10.61	8.04
05/04/2001 12:00	13.22	8.55	05/06/2001 2:00	10.84	8.05
05/04/2001 13:00	12.97	8.57	05/06/2001 3:00	11	8.05
05/04/2001 14:00	12.8	8.57	05/06/2001 4:00	11.2	8.07
05/04/2001 15:00	12.24	8.49	05/06/2001 5:00	11.38	8.07
05/04/2001 16:00	12.37	8.45	05/06/2001 6:00	11.53	8.07
05/04/2001 17:00	12.11	8.37	05/06/2001 7:00	12.04	8.1
05/04/2001 18:00	11.76	8.3	05/06/2001 8:00	13.2	8.21
05/04/2001 19:00	10.97	8.21	05/06/2001 9:00	13.81	8.29
05/04/2001 20:00	10.04	8.11	05/06/2001 10:00	14.01	8.49
05/04/2001 21:00	9.81	8.02	05/06/2001 11:00	13.87	8.54
05/04/2001 22:00	9.94	8.01	05/06/2001 12:00	13.56	8.63

DateTime M/D/Y	DO Conc mg/L	pH	DateTime M/D/Y	DO Conc mg/L	pH
05/06/2001 13:00	13.19	8.6	05/08/2001 3:00	10.74	7.99
05/06/2001 14:00	12.96	8.58	05/08/2001 4:00	10.99	8.02
05/06/2001 15:00	12.63	8.54	05/08/2001 5:00	11.11	8.03
05/06/2001 16:00	12.26	8.46	05/08/2001 6:00	11.3	8.05
05/06/2001 17:00	11.8	8.36	05/08/2001 7:00	11.77	8.08
05/06/2001 18:00	11.37	8.25	05/08/2001 8:00	12.93	8.18
05/06/2001 19:00	10.45	8.18	05/08/2001 9:00	13.57	8.27
05/06/2001 20:00	9.42	8.02	05/08/2001 10:00	13.84	8.44
05/06/2001 21:00	9.25	7.91	05/08/2001 11:00	13.69	8.5
05/06/2001 22:00	9.55	7.9	05/08/2001 12:00	13.4	8.57
05/06/2001 23:00	9.83	7.91	05/08/2001 13:00	12.99	8.55
05/07/2001 0:00	10.15	7.94	05/08/2001 14:00	10.95	8.31
05/07/2001 1:00	10.46	7.96	05/08/2001 15:00	11.64	8.29
05/07/2001 2:00	10.69	7.99	05/08/2001 16:00	11.14	8.26
05/07/2001 3:00	10.94	8.02	05/08/2001 17:00	9.95	8.11
05/07/2001 4:00	11.12	8.04	05/08/2001 18:00	10.58	8.11
05/07/2001 5:00	11.31	8.06	05/08/2001 19:00	10.49	8.13
05/07/2001 6:00	11.45	8.06	05/08/2001 20:00	9.36	8.02
05/07/2001 7:00	11.92	8.09	05/08/2001 21:00	9.2	8
05/07/2001 8:00	13.03	8.19	05/08/2001 22:00	9.37	7.98
05/07/2001 9:00	13.7	8.27	05/08/2001 23:00	9.68	7.97
05/07/2001 10:00	13.9	8.43	05/09/2001 0:00	9.88	7.97
05/07/2001 11:00	13.83	8.53	05/09/2001 1:00	10.11	7.99
05/07/2001 12:00	13.55	8.58	05/09/2001 2:00	10.25	8.01
05/07/2001 13:00	13.16	8.57	05/09/2001 3:00	10.22	8.03
05/07/2001 14:00	12.56	8.54	05/09/2001 4:00	10.01	8.02
05/07/2001 15:00	12.29	8.5	05/09/2001 5:00	10.38	8.01
05/07/2001 16:00	11.9	8.4	05/09/2001 6:00	10.45	8
05/07/2001 17:00	11.59	8.29	05/09/2001 7:00	10.97	8.03
05/07/2001 18:00	11.09	8.2	05/09/2001 8:00	12.09	8.14
05/07/2001 19:00	10.13	8.08	05/09/2001 9:00	12.91	8.27
05/07/2001 20:00	9.15	8.01	05/09/2001 10:00	13.17	8.43
05/07/2001 21:00	9.07	7.87	05/09/2001 11:00	13.06	8.52
05/07/2001 22:00	9.34	7.85	05/09/2001 12:00	12.66	8.56
05/07/2001 23:00	9.6	7.86	05/09/2001 13:00	12.15	8.54
05/08/2001 0:00	10.01	7.9	05/09/2001 14:00	11.81	8.48
05/08/2001 1:00	10.2	7.93	05/09/2001 15:00	11.06	8.38
05/08/2001 2:00	10.52	7.97	05/09/2001 16:00	10.28	8.19

DateTime M/D/Y	DO Conc mg/L	pH	DateTime M/D/Y	DO Conc mg/L	pH
05/09/2001 17:00	8.96	8.07	06/21/2001 8:00	9.61	8.19
05/09/2001 18:00	8.8	8.05	06/21/2001 9:00	9.8	8.25
05/09/2001 19:00	10.07	8.12	06/21/2001 10:00	9.69	8.32
05/09/2001 20:00	9.17	8.05	06/21/2001 12:00	9.12	8.37
05/09/2001 21:00	8.98	7.98	06/21/2001 13:00	8.78	8.37
05/09/2001 22:00	9.12	7.97	06/21/2001 14:00	7.82	8.12
05/09/2001 23:00	9.4	7.96	06/21/2001 15:00	8.62	8.24
05/10/2001 0:00	9.34	7.98	06/21/2001 16:00	8.67	8.24
05/10/2001 1:00	9.71	7.99	06/21/2001 17:00	8.89	8.23
05/10/2001 2:00	9.85	7.99	06/21/2001 18:00	8.64	8.26
05/10/2001 3:00	9.97	8.01	06/21/2001 19:00	8.41	8.23
05/10/2001 4:00	10.13	8.02	06/21/2001 20:00	8.05	8.13
05/10/2001 5:00	10.29	8.03	06/21/2001 21:00	7.95	8.07
05/10/2001 6:00	10.02	8.03	06/21/2001 22:00	8.04	8.07
05/10/2001 7:00	10.9	8.04	06/21/2001 23:00	8.16	8.07
05/10/2001 8:00	12.02	8.15	06/22/2001 0:00	8.28	8.08
05/10/2001 9:00	13.11	8.26	06/22/2001 1:00	8.36	8.08
06/20/2001 11:00	11.29	8.24	06/22/2001 2:00	8.35	8.07
06/20/2001 12:00	9.49	8.3	06/22/2001 3:00	8.42	8.06
06/20/2001 13:00	8.83	8.25	06/22/2001 4:00	8.45	8.06
06/20/2001 14:00	8.52	8.23	06/22/2001 5:00	8.49	8.07
06/20/2001 15:00	7.76	8.06	06/22/2001 6:00	8.51	8.07
06/20/2001 16:00	7.62	8.1	06/22/2001 7:00	8.85	8.11
06/20/2001 17:00	7.86	8.11	06/22/2001 8:00	9.44	8.21
06/20/2001 18:00	8.63	8.18	06/22/2001 9:00	9.6	8.28
06/20/2001 19:00	8.5	8.18	06/22/2001 10:00	9.57	8.33
06/20/2001 20:00	8.18	8.13	06/22/2001 11:00	9.35	8.39
06/20/2001 21:00	8.03	8.07	06/22/2001 12:00	9.11	8.4
06/20/2001 22:00	8.1	8.05	06/22/2001 13:00	8.83	8.4
06/20/2001 23:00	8.16	8.04	06/22/2001 14:00	8.55	8.37
06/21/2001 0:00	8.24	8.05	06/22/2001 15:00	8.29	8.35
06/21/2001 1:00	8.29	8.05	06/22/2001 16:00	8.26	8.28
06/21/2001 2:00	8.38	8.07	06/22/2001 17:00	8.04	8.22
06/21/2001 3:00	8.49	8.08	06/22/2001 18:00	7.55	8.23
06/21/2001 4:00	8.56	8.08	06/22/2001 19:00	7.74	8.18
06/21/2001 5:00	8.66	8.08	06/22/2001 20:00	7.67	8.16
06/21/2001 6:00	8.75	8.08	06/22/2001 21:00	7.55	8.09
06/21/2001 7:00	9.07	8.11	06/22/2001 22:00	7.71	8.09

DateTime M/D/Y	DO Conc mg/L	pH	DateTime M/D/Y	DO Conc mg/L	pH
06/22/2001 23:00	7.83	8.09	06/24/2001 13:00	8.4	8.35
06/23/2001 0:00	7.95	8.08	06/24/2001 14:00	8.53	8.37
06/23/2001 1:00	8.03	8.08	06/24/2001 15:00	8.29	8.36
06/23/2001 2:00	8.11	8.08	06/24/2001 16:00	8.34	8.31
06/23/2001 3:00	8.21	8.1	06/24/2001 17:00	8.37	8.24
06/23/2001 4:00	8.3	8.1	06/24/2001 18:00	8.15	8.31
06/23/2001 5:00	8.42	8.1	06/24/2001 19:00	7.95	8.25
06/23/2001 6:00	8.41	8.09	06/24/2001 20:00	7.61	8.18
06/23/2001 7:00	8.63	8.1	06/24/2001 21:00	7.37	8.1
06/23/2001 8:00	9.3	8.19	06/24/2001 22:00	7.54	8.09
06/23/2001 9:00	9.52	8.27	06/24/2001 23:00	7.7	8.1
06/23/2001 10:00	9.5	8.33	06/25/2001 0:00	7.84	8.1
06/23/2001 11:00	9.28	8.39	06/25/2001 1:00	7.93	8.11
06/23/2001 12:00	9	8.39	06/25/2001 2:00	8	8.11
06/23/2001 13:00	8.68	8.39	06/25/2001 3:00	8.04	8.07
06/23/2001 14:00	8.46	8.37	06/25/2001 4:00	8.05	8.07
06/23/2001 15:00	8.14	8.26	06/25/2001 5:00	8.03	8.06
06/23/2001 16:00	8.52	8.28	06/25/2001 6:00	8.06	8.06
06/23/2001 17:00	7.72	8.14	06/25/2001 7:00	8.29	8.09
06/23/2001 18:00	7.73	8.24	06/25/2001 8:00	8.49	8.13
06/23/2001 19:00	7.78	8.23	06/25/2001 9:00	9.04	8.21
06/23/2001 20:00	7.52	8.16	06/25/2001 10:00	8.87	8.26
06/23/2001 21:00	7.52	8.12	06/25/2001 11:00	8.74	8.24
06/23/2001 22:00	7.66	8.1	06/25/2001 12:00	9.25	8.27
06/23/2001 23:00	7.81	8.11	06/25/2001 13:00	9.42	8.38
06/24/2001 0:00	7.96	8.12	06/25/2001 14:00	9.15	8.41
06/24/2001 1:00	8.08	8.12	06/25/2001 15:00	8.95	8.37
06/24/2001 2:00	8.2	8.12	06/25/2001 16:00	8.77	8.37
06/24/2001 3:00	8.25	8.12	06/25/2001 17:00	8.5	8.29
06/24/2001 4:00	8.31	8.1	06/25/2001 18:00	8.25	8.2
06/24/2001 5:00	8.33	8.09	06/25/2001 19:00	7.98	8.2
06/24/2001 6:00	8.37	8.09	06/25/2001 20:00	7.78	8.17
06/24/2001 7:00	8.81	8.14	06/25/2001 21:00	7.54	8.1
06/24/2001 8:00	9.35	8.23	06/25/2001 22:00	7.65	8.09
06/24/2001 9:00	9.52	8.28	06/25/2001 23:00	7.9	8.13
06/24/2001 10:00	9.46	8.35	06/26/2001 0:00	7.97	8.12
06/24/2001 11:00	9.26	8.39	06/26/2001 1:00	7.97	8.09
06/24/2001 12:00	8.99	8.41	06/26/2001 2:00	7.86	8.04

DateTime M/D/Y	DO Conc mg/L	pH
06/26/2001 3:00	7.68	7.97
06/26/2001 4:00	7.66	7.95
06/26/2001 5:00	7.82	7.98
06/26/2001 6:00	7.93	7.98
06/26/2001 7:00	8.29	8.03
06/26/2001 8:00	8.86	8.13
06/26/2001 9:00	9	8.22
06/26/2001 10:00	9.32	8.26
06/26/2001 11:00	9.16	8.37
06/26/2001 12:00	8.88	8.39
06/26/2001 13:00	8.49	8.39
06/26/2001 14:00	8.41	8.37
06/26/2001 15:00	7.6	8.32
06/26/2001 16:00	7.87	8.22
06/26/2001 17:00	8.15	8.25
06/26/2001 18:00	8.07	8.26
06/26/2001 19:00	8.15	8.27
06/26/2001 20:00	7.54	8.2
06/26/2001 21:00	7.38	8.12
06/26/2001 22:00	7.55	8.1
06/26/2001 23:00	7.71	8.1
06/27/2001 0:00	7.82	8.1
06/27/2001 1:00	7.91	8.09
06/27/2001 2:00	8	8.09
06/27/2001 3:00	8.1	8.09
06/27/2001 4:00	8.17	8.09
06/27/2001 5:00	8.25	8.08
06/27/2001 6:00	8.31	8.09
06/27/2001 7:00	8.73	8.13
06/27/2001 8:00	8.91	8.17
06/27/2001 9:00	9.39	8.25
06/27/2001 10:00	9.32	8.32
06/27/2001 11:00	9.11	8.36

Appendix C: Calculation of the 4Q3

The regression model developed for the 52 gaging stations in physiographic regions in New Mexico is as follows:

$$4Q3 = 1.409 \times 10^{-4} DA^{0.43} P_w^{3.11}$$

Where;

4Q3 = 4-day, 3-year, low-flow frequency, in cubic feet per second;

DA = drainage area, in square miles; and

P_w = average basin mean winter precipitation 1961-1990, in mm

Mangas Creek:

P_w = 2468.775

DA = 203

Slope = 0.179

Elevation = 5730

$$0.54 \text{ cfs} = 1.409 \times 10^{-4}(203)^{0.43}(2468.775)^{3.11}$$

Appendix D: 2001 Nutrient Data for Mangas Creek

2001 Nutrient Data for Mangas Creek

Analyte	Result	Units	Date	Location
Nitrate and Nitrite	**14.2**	mG/L	03/08/2001	Mangas Below the Springs
	9.6	mG/L	06/19/2001	Mangas Below the Springs
	14	mG/L	06/27/2001	Mangas Above the Springs
Ammonia	<0.1	mG/L	03/08/2001	Mangas Below the Springs
	<0.1	mG/L	06/19/2001	Mangas Below the Springs
	<0.1	mG/L	06/27/2001	Mangas Above the Springs
TKN	<0.1	mG/L	03/08/2001	Mangas Below the Springs
	<0.1	mG/L	06/19/2001	Mangas Below the Springs
	<0.1	mG/L	06/27/2001	Mangas Above the Springs
Total Phosphorus	0.07	mG/L	03/08/2001	Mangas Below the Springs
	<0.03	mG/L	06/19/2001	Mangas Below the Springs
	0.044	mG/L	06/27/2001	Mangas Above the Springs

Appendix E: Limiting Nutrient and Algal Bioassay (Abrieviated version)

Algal Growth Potential (AGP) Assays

on

Water from the Gila Area

to

State Of New Mexico
Environment Department
1190 St. Francis Drive
P.O. Box 26110
Santa Fe, New Mexico 87502

submitted to

Julie Tsatsaros

July 30, 2001

by

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Albuquerque, NM 87131
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Background:

The water was collected on 06-18/19/20/21-01 and transported on ice to our laboratory. The initial tests for growth potential were initiated two days later and were terminated after 14 days of incubation. Water fom each site was autoclaved and filtered, and stored at 4^0 C for one week before the 14 day study concerning additions of nitrogen and phosphorus was initiated.

The procedures used for determining limiting nutrients and toxicity to algae was as established in the EPA-600/9-78-018 publication entitled "The *Selenastrum Capricornutum* Prinz Algal Assay Bottle Test" and EPA-660/3-75-034 publication entitled "Proceedings: Biostimulation/and/ Nutrient Assessment Workshop" The design is as follows:

Water from the creeks/rivers was autoclaved and passed through filters which had a pore diameter of 0.4 micrometers. The filtered water, 25 ml, was placed in 125 ml Erlenmeyer flasks which were covered with aluminum foil. Each assay was conducted in triplicate under laboratory conditions with continual fluorescent lighting.

The design of the test for algal growth potential is as listed below:

1. Control (filtered river water with no additions)
2. Control + 0.05 mg P/liter
3. Control + 1.00 mg N/liter
4. Control + 1.00 mg N + 0.05 mg P /liter
5. Control + 1.00 mg Na_2 EDTA/liter
6. Control + 1.00 mg Na_2 EDTA + 0.05 mg P/liter
7. Control + 1.00 mg Na_2 EDTA + 1.00 mg N/liter
8. Control + 1.00 mg Na_2 EDTA + 1.00 mg N + 0.05 mg P/liter
9. Control + 1.00 mg Na_2 EDTA + 1.00 mg N + 0.05 mg P + 4.5 g Fe/liter

At the end of 10 days of incubation, the amount of chlorophyll was determined using fluoresence measurements. The fluorescence values were converted to dry weight values using a standard that we had constructed. The results are given in dry weight measurements as is in accordance with the EPA procedure.

The water samples were designated as follows:

Designation	Site of collection
I	San Francisco River above Luna
II	Center Fire Creek at Spur Ranch
III	Lower Mangas Creek
IV	Canyon Creek

The following statements can be made concerning the individual waters:

San Francisco River above Luna

1. The river water is limiting in nitrogen. When nitrogen is added (see Figure 1) the growth response is linear up to 2.5 mg/L.
2. There is adequate phosphorus in the water to support algal growth even when the amount of nitrogen supplemented is 2.5 mgN/L.
3. As evidenced by the lack of stimulation with the presence of EDTA, there was no toxicity due to heavy metals.

Centerfire Creek at Spur Ranch

The water is slightly limiting in nitrogen. That is, when 0.25 N/L is added, the growth is stimulated; however, further additions of nitrogen do not stimulate algal growth. This indicates that something other than nitrogen becomes limiting. Slight limitation of phosphorus is noted (see Figure 5). Additions of 0.01 and 0.025 mg phosphorus/L stimulates growth; however, further additions do not increase growth. As evidenced by the lack of stimulation with the presence of EDTA, there was no toxicity due to heavy metals.

Lower Mangas Creek

1. The water is not low in available nitrogen because with the addition of nitrogen, there is no increase in algal growth. See Figure 3.
2. The water is definitely low in phosphorus because with the addition of phosphorus (Figure 6) there is nearly linear increase in algal growth.

   As evidenced by the lack of stimulation with the presence of EDTA, there was no toxicity due to heavy metals. Without added nutrients, water from Mangas Creek supported nearly four times the algal biomass as did water from San Francisco and Center Fire sites.

Canyon Creek

1. The water is nitrogen limited in that the addition of nitrogen stimulates algal growth. See Figure 4. Additions of nitrogen up to 1 mg/L give a linear increase in the amount of growth; however, growth above 1 mgN/L is stimulated at a lower level.
2. There is no indication that the water is limiting in phosphorus.
3. As evidenced by the lack of stimulation with the presence of EDTA, there was no toxicity due to heavy metals.
4. Without added nutrients, water from Canyon Creek supported twice the algal biomass as did water from the San Francisco and Center Fire sites.

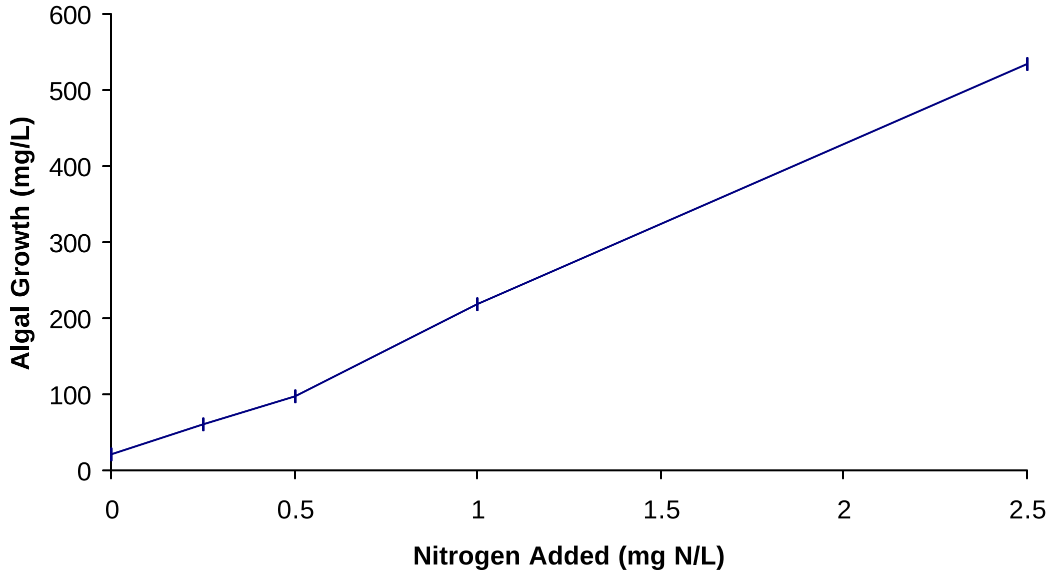

Figure 1 – San Francisco River above Luna

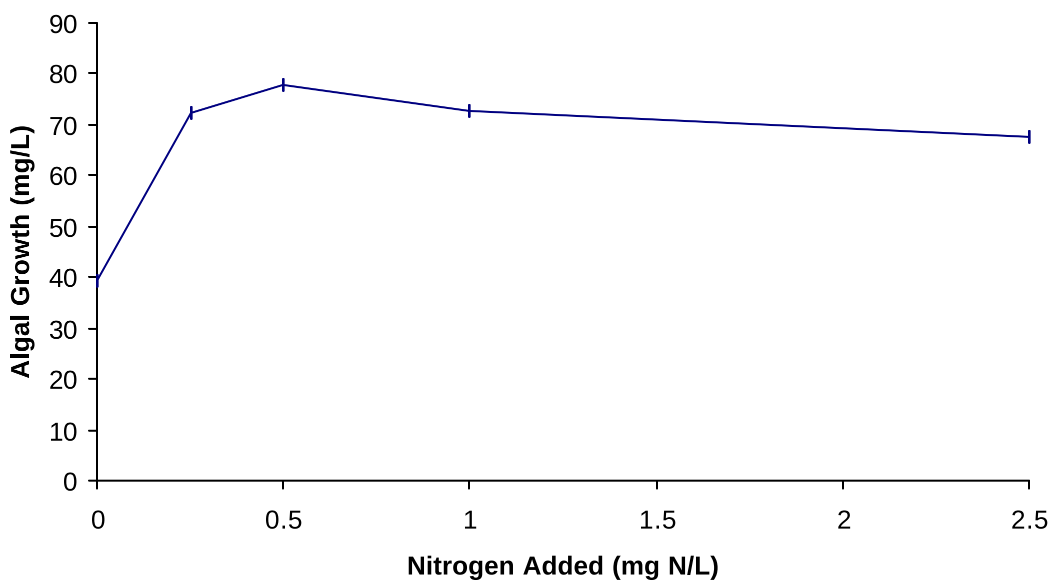

Figure 2 – Center Fire Creek at Spur Ranch

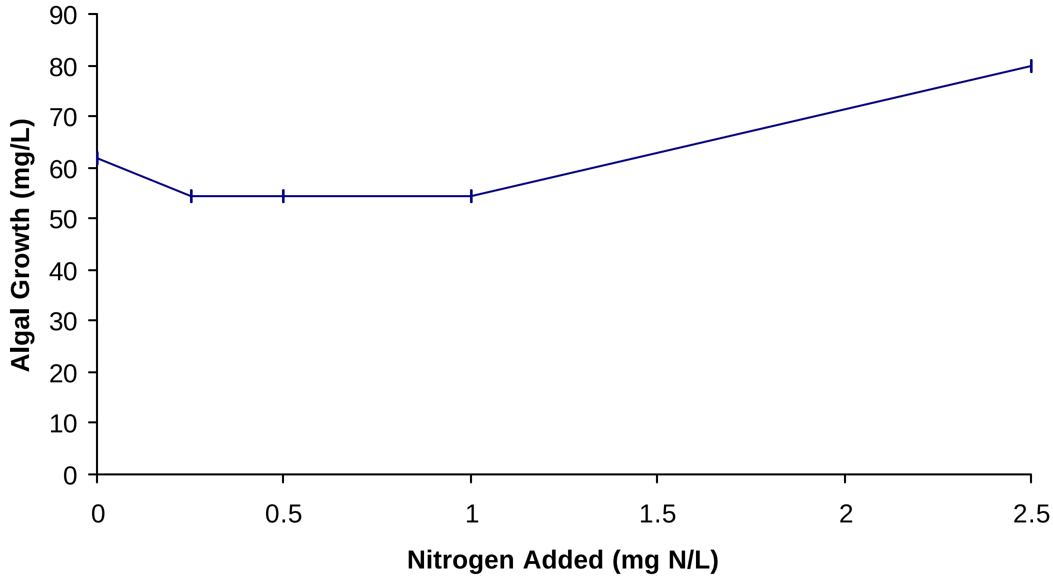

Figure 3 – Lower Mangas Creek

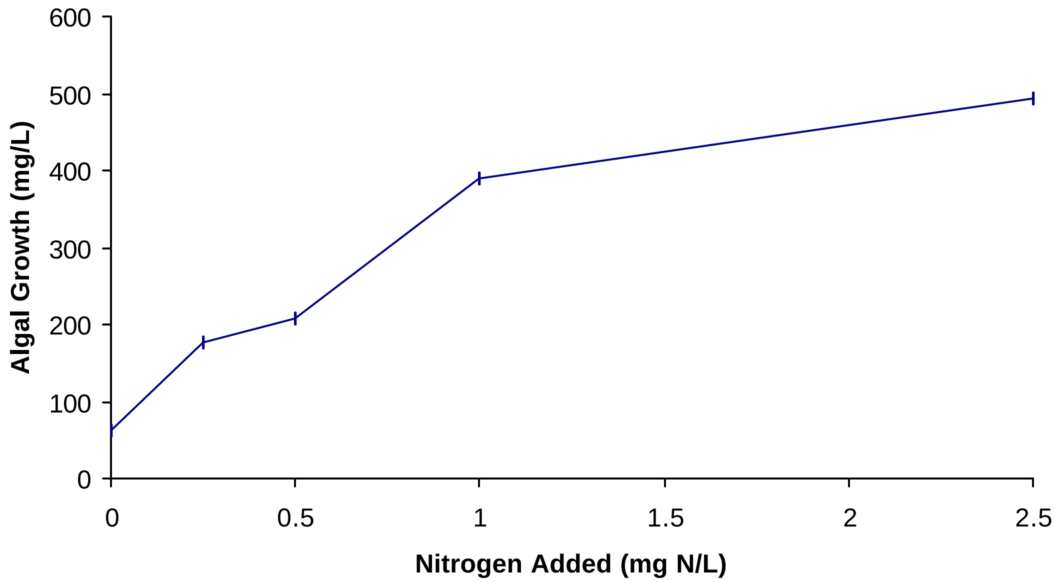

Figure 4 – Canyon Creek

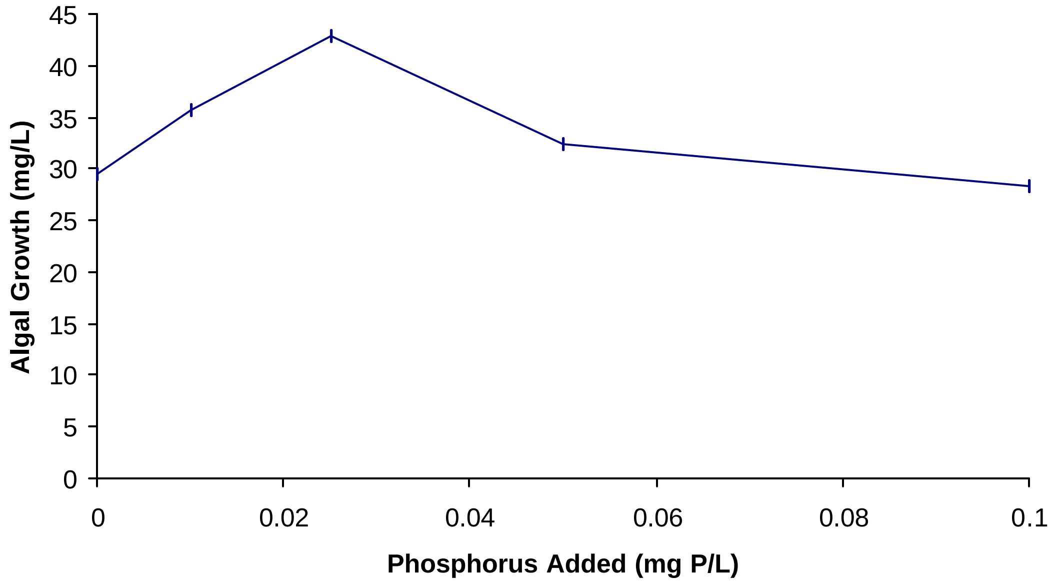

Figure 5 – Center Fire Creek at Spur Ranch

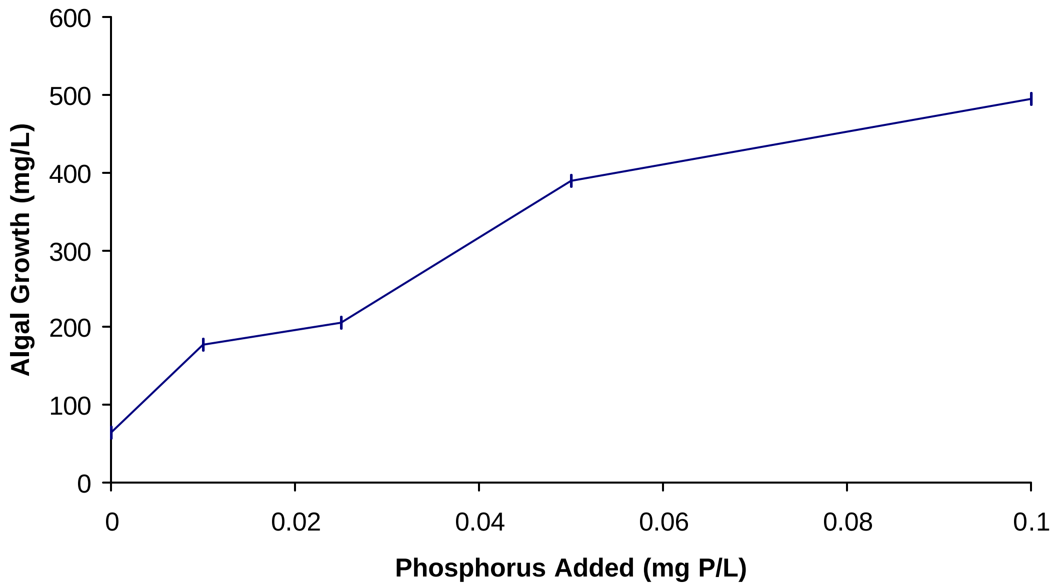

Figure 6 – Lower Mangas Creek

Appendix F: Nutrient Assessment Protocol

NUTRIENT ASSESSMENT PROTOCOL FOR STREAMS

New Mexico Environment Department
Surface Water Quality Bureau

July 2000

Nutrient Assessment Protocol For Streams

Purpose

The purpose of this document is to establish an assessment protocol for the determination of nutrient enrichment of streams. There is no numeric standard for nutrients in New Mexico. The narrative standard reads, "plant nutrients from other than natural causes shall not be present in concentrations which will produce undesirable aquatic life or result in a dominance of nuisance species in surface waters of the state (NMWQCC 2000)". This protocol will be used to assess the need for a TMDL on a reach that is listed on the State of New Mexico's 303 (d) list as impaired by plant nutrients.

Background

The presence of some aquatic vegetation is normal in streams. Algae and macrophytes provide habitat and food for all stream animals. However, an excessive amount of aquatic vegetation is not beneficial to most stream life. The level of nutrient enrichment is often reflected by the types and amounts of aquatic vegetation in the water. High levels of nutrients (especially nitrogen and phosphorus) may promote an overabundance of algae and floating and rooted macrophytes.

Plant respiration and decomposition of dead vegetation consume dissolved oxygen in the water. Lack of dissolved oxygen creates stress for all aquatic organisms and can cause fish kills. A landowner may have seen fish gulping for air at the water surface during warm weather, indicating a lack of dissolved oxygen (DO). Increases in primary productivity can increase invertebrates and fish in streams. However, excessive plant growth and decomposition can limit aquatic populations by decreasing dissolved oxygen concentrations. Nocturnal respiration can cause oxygen depletion in waters with high primary productivity and low reaeration rates. Even relatively small reductions in dissolved oxygen can have adverse effects on both invertebrate and fish communities (EPA 1991). Saturation levels of greater than 115% have been shown to be harmful to aquatic life (Behar 1996). Development of anaerobic conditions will alter a wide range of chemical equilibria, and may mobilize certain pollutants and generate noxious odors (EPA 1991).

Assessment Procedure

The primary question to be answered is: Is this reach nutrient impaired, and is the area of impairment large enough to cause undesirable water quality changes? A nutrient impaired reach occurs where algal and macrophyte growths interfere with beneficial uses such as primary contact recreation, and high quality coldwater fishery etc. Algal biomass is the most important indicator of nutrient enrichment. Algae are either the direct (excessive, unsightly periphyton mats or surface plankton scums) or indirect (high/low DO and pH and high turbidity) cause of most problems related to excessive nutrient enrichment.

Algal and macrophyte growths may be determined to be a nuisance when there is 1) rotting algae and macrophytes in the stream, 2) substrate in the stream are choked with algae, 3) there are diurnal fluctuations in DO and pH, and/or 4) a release of sediment bound toxins. The EPA criteria for levels of periphyton biomass that are a nuisance are 150 mg^2/m^2 chlorophyll *a*.

This protocol should be applied in the field during critical seasons, especially during low flow periods such as summer and early fall. Normally, during this time there is more potential to have higher concentrations of plant nutrients in the stream, higher water and air temperatures, decreased periods of scouring, and maximum solar gain. This protocol consists of three levels, which range from a visual to analytical assessments. The different levels of assessment are used in sequential order to determine occurrence of nutrient over enrichment. Level I focuses on visual observations of a system and will usually provide enough information to determine whether a reach is impaired by plant nutrients, although it is often useful to continue with a Level II analysis. A Level II assessment combines analysis of chemical and biological samples to characterize the benthic community and water chemistry. If these measures contain exceedances of surface water quality standards, indicators of excessive primary production (i.e. large D.O. and pH fluctuation and/or high chlorophyll a concentration) or there is an unhealthy benthic community a Level III analysis can be performed. Level III analysis involves more quantitative measures and focuses on the algal and macrophyte community dynamics.

If it is determined that a stream reach is nutrient enriched, a TMDL will be written for that reach. Nutrient enrichment can be determined following a Level I analysis. In most cases, a level II-III analysis will be used to confirm this conclusion.

Level I: Observational with Limited Measures

The following measurement and observations should be made to assess for nutrient enrichment. If any of the measures are apparent, then there would be a strong indication of nutrient enrichment, and the analysis would move to a level II. If a reach is considered "borderline" a more intensive level II-III assessment would be made to further verify.

Location: **Mangas Creek from the mouth on the Gila to Mangas 06/19/01**

- Determine the presence of excess growth of algae and/or macrophytes. Record a visual estimate of percent algae coverage. Look for lush and deep green thick mats of algae, and dense stands of macrophytes. Coverages of greater than 70% may indicate excessive nutrient enrichment. Also note the presence of algae and macrophytes in the stream, substrate that is choked with algae and/or macrophytes, and where in the stream the growth is occurring (i.e. only on low flow areas, on fine substrate, or large stable substrate etc).

Dense mats of filamentous algae, anywhere the flow was not high previously to scour, 30-40% filamentous algae. Big storm event in the watershed one week previous. 85-90% of substrate is covered with algae.

- Measure dissolved oxygen (D.O.); field measurement should be measured in the late afternoon. Determine if the D.O. concentration is above 110% saturation. Only algal production will cause supersaturated DO and high pH during the day. If a D.O. measurement can be taken at night, determine if the concentration exceeds surface water quality standards for that reach. Nocturnal respiration can cause oxygen depletion in waters with high primary productivity and low reaeration rates.

DO was between 103-108% of saturation when sonde was deployed on 6/19/2001 (see Appendix B)

- Measure the pH during the late afternoon. High pH is indicative of eutrophic conditions. Determine if the pH exceeds 9 or the standard for the stream reach.

8.29 ntu when sonde was deployed on 6/19/2001 (see Appendix B)

- Evaluate the coarse substrata (cobbles, boulders, and sand). Note the dominance and subdominant size classes. Look for the presence of slime on the coarse substrate. Note the occurrence and character of the slime (i.e. which substrate it occurs on, its thickness and color etc.). This slime is periphyton and may develop in response to nutrient enrichment.

Gravels - 85-90% of substrate covered with algae

- Identify possible known sources of plant nutrients (i.e., septic, point source, confined animal feeding operations, residential development, fertilizers on agricultural land etc.) utilizing SWQB/NMED 1996b, observations of land use and other sources.

Natural springs, Mangas spring is approximately 4 miles upstream, upstream septic systems, grazing

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- Gather existing data. Compile data on water quality, aquatic communities, land use, etc. for the reach of concern and associated watershed. Determine if the existing data (chemical, biological, land use, etc.) substantiates observational findings?

See previous reports in file, historic data for macroinvertebrates states full support/impacts observed

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- Observe the color and clarity of the water. Measure the turbidity. Green colored water can indicate the presence of phytoplankton and high levels of total suspended solids (TSS) and turbidity. TSS attenuates light and decreases transparency. High levels of light and TSS and turbidity affect the response of algae to nutrients due to light attenuation and scouring. TSS in the range of 10-32 mg/L and turbidity in the range of 7-23 NTU may reduce abundance and diversity of benthic macrophytes to graze on the algae (EPA Guidance 1998).

32 ntu (also Appendix B)

- Note if black fly larvae or other diptera dominate benthic community

No not a lot of diptera, mayflies, caddisflies

- Estimate the extent of the impacted area (i.e. the distance of the stream that is impaired.

All perennial portions

- Note where the indicators of nutrient enrichment change.

?

- Determine if the stream discharges to an impoundment.

No

- Note the dominant velocity of the flow. The flow velocity influences algal growth. High flow events can scour the stream channel and reduce algal biomass. Reduced flows may produce drought conditions leading to low levels of algal biomass. Stable, moderate flows that provide plant nutrients may increase eutrophication problems.

3-5 cfs

- Observe the riparian corridor. Record the character of the riparian area noting the height, density and removal of streamside vegetation (rivers need adequate light to develop and maintain high levels of algal biomass), so, an assessment of streamside vegetation will be necessary to determine if there is sufficient light to support an algal bloom.

Not a lot of riparian vegetation.

Level II: Limited Quantitative Measures Taken

Before selecting locations for sampling, walk a couple of hundred meters of the stream to ensure the sampling stations are representative (i.e. are not atypical) of the reach being characterized. The following data should be collected from each site:

- Three to fourteen days of continuous sonde data of dissolved oxygen, pH, conductivity, temperature, and turbidity. Observe predawn measurements for diurnal minimum dissolved oxygen concentrations and afternoon hours for maximum pH. Aquatic organisms are affected most by maximum pH and minimum DO rather than by daily means for those variables.

See May and June 2001 sonde data (Appendix B)

- Water samples should be collected for analysis of nutrient concentrations including total phosphorus and nitrogen. Soluble reactive phosphorus and dissolved inorganic nitrogen are the forms available for algal uptake, and are the forms determined (after digestion) for total nitrogen and total phosphorus (EPA Guidance 1998).

See Appendix D

- Algal metabolic rate at a given biomass and growth phase is controlled by temperature, in addition to water movement, nutrients, and light. Nutrient sampling should be conducted monthly to bimonthly during the season of greatest nutrient loading and during the season of greatest algal growth. Some nutrient sampling should also occur during the season of lowest algal biomass levels.

See Appendix D

- Chlorophyll a concentration should be measured by collecting a sample from a known area of substrate or from an artificial substrate (i.e. slides). Chlorophyll *a* concentration is used as a surrogate for algal biomass. **An algal indicator such as chlorophyll *a* is generally the most appropriate monitoring technique (EPA 1991).** Chlorophyll *a* values < 50 mg/m^2 are typical of unenriched or light scoured streams (EPA Guidance 1998). EPA (1998) guidance states that British Columbia developed algal biomass criteria for small wadeable streams: 50 mg/L of chlorophyll a to protect aesthetics, and 100 mg/L to protect against undesirable changes in stream communities.

See Appendix E

- Chlorophyll a is specific to algae, while Ash Free Dry Mass (AFDM) and turbidity includes living and non-living organic matter. **AFDM/Chlorophyll a is an autotrophic index for periphyton productivity, which can distinguish the relative response to inorganic nitrogen, phosphorus and biological oxygen demand (BOD) enrichment.** Streams enriched with inorganic nutrients that have eutrophication problems have ratios of AFDM/chlorophyll a >250, values > 400 indicate organically polluted conditions (EPA 1998).

See Appendix E

- Samples of benthic macroinvertebrates should be collected from the reach being characterized and a suitable reference site. In areas where other stressors such as sediment are not shown to be causing an impairment to the biological community, an assessment using metrics specific to organic enrichment such as the Hilsenhoff Biotic Index, or others as appropriate, should be conducted. **Indices employing macroinvertebrates as indicators of nutrient pollution have great potential. They are the most reliable and frequently used organisms to assess water quality (EPA 1998).** Macroinvertebrates are highly sensitive to changes in water quality and disturbance and are relatively immobile. They are also long lived and easy to sample, and are an important food supply for fish. Karr developed a 10 metric B-IBI index for macroinvertebrates to evaluate the effects of nutrient enrichment.

Macroinvertebrates taken at this site previously

- The ideal sampling procedure to survey the biological community would be to **sample each change of season, and then select appropriate sampling periods that accommodate seasonal variation (EPA 1996).** This ensures sources of ecological disturbance will be monitored and trends documented, and additional information will be available in the event of spills etc. Therefore, the response of the biological community to eposodic events can be assessed (EPA 1996).

Level III: Extensive Quantitative Measures Taken (Diatoms, Phytoplankton, IBA)

Level III analysis uses information gathered in Level I and II assessments combined with additional information that provides a more quantitative measure of over enrichment. In streams benthic algae production and biomass are the most useful of all aquatic flora parameters in monitoring changes in water quality (EPA 1991). Periphyton algal biomass above nuisance levels often produces wide diurnal swings in water quality variables. The use of models such as CE-QUAL-RIV1, QUAL2E, and FORTRAN can be very useful to assess aspects of nutrient overenrichment. CE-QUAL-RIV1 simulates water quality conditions with the highly unsteady flows that can occur in regulated rivers. QUAL2E allows simulation of diurnal variations in temperature or algal photosynthesis and enrichment. FORTRAN simulates water quality and quantity for a wide range of organic and inorganic pollutants from agricultural watersheds (EPA Guidance 1998). The qualitative measures to be taken for Level III Assessment include:

- Identify a reference reach for the test reach and compare the characteristics of the sites including algal biomass, algal community composition, benthic community composition and associated environmental conditions (such as nutrient concentrations, light, canopy cover, substrate, DO and pH).

In streams, benthic algae production and biomass are the most useful of all aquatic flora parameters to monitor changes in water quality (EPA 1991). Periphyton algal biomass above nuisance levels often produces wide diurnal swings in water quality variables due to metabolism.

- River algal growth is likely related to nutrient levels during the season of greatest algal growth. **Generally, sampling once a month from June to September is adequate to assess algal biomass**. Although, if the algal biomass is high enough to cause excessive DO/pH fluctuations that violate water quality standards, then the time frames for those water quality violations should be judged for the accessibility of algal biomass levels (EPA 1996).

- **For benthic algae, biomass, species richness, diversity, and productivity can be measured from natural or artificial substrates.** To reduce variability, algae should be sampled in the part of the stream where algae is most likely to conflict with beneficial uses. A sample of algae should be collected from a known area of natural or artificial substrates and filtered onto glass filter fibers for analysis of chlorophyll a concentration and biomass determination. A sample should also be preserved with formalin for identification. **An autotrophic index can be obtained by measuring the accumulation of organic material (ie. Biomass) on artificial substrates over a period of one to two weeks.** Until more is known about the natural variability of these parameters, the Chlorophyll a concentration, biomass, and algal composition should be compared to the reference site(s) as well as EPA guidance.

- Benthic macroinvertebrate samples should also be collected from the test reach and a reference site. The benthic community can be assessed using the 1999 RBP. This index of biological integrity (B-IBI) for macroinvertebrates uses a number of metrics that are non-specific to waste type and can evaluate effects of nutrient enrichment (eg. Number of taxa, percent EPT-mayflies, stoneflies, and caddisflies, percent predators etc.). The advantages of the B-IBI include: low variability and high sensitivity, and absolute background values for a no effect condition (EPA Guidance 1998).

References:

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Appendix G: Pollutant Source(s) Documentation Protocol

POLLUTANT SOURCE(S) DOCUMENTATION PROTOCOL

New Mexico Environment Department
Surface Water Quality Bureau
July 1999

This protocol was designed to support federal regulations and guidance requiring states to document and include probable source(s) of pollutant(s) in their §303(d) Lists as well as the States §305(b) Report to Congress.

The following procedure should be used when sampling crews are in the field conducting water quality surveys or at any other time field staff are collecting data.

Pollutant Source Documentation Steps:

1). Obtain a copy of the most current §303(d) List.

2). Obtain copies of the **Field Sheet for Assessing Designated Uses and Nonpoint Sources of Pollution**.

3). Obtain digital camera that has time/date photo stamp on it from the Watershed Protection Section.

4). Obtain GPS unit and instructions from Neal Schaeffer.

5). Identify the reach(s) and probable source(s) of pollutant in the §303(d) List associated with the project that you will be working on.

6). Verify if current source(s) listed in the §303(d) List are accurate.

7). Check the appropriate box(s) on the field sheet for source(s) of nonsupport and estimate percent contribution of each source.

8). Photodocument probable source(s) of pollutant.

9). GPS the probable source site.

10). Give digital camera to Gary King for him to download and create a working photo file of the sites that were documented.

11). Give GPS unit to Neal Schaeffer for downloading and correction factors.

12). Enter the data off of the **Field Sheet for Assessing Designated Uses and Nonpoint Sources of Pollution** into the database.

13). Create a folder for the administrative files, insert field sheet and photodocumentation into the file.

This information will be used to update §303(d) Lists and the States §305(b) Report to Congress.

FIELD SHEET FOR ASSESSING DESIGNATED USES AND NONPOINT SOURCES OF POLLUTION

CODES FOR USES NOT FULLY SUPPORTED

☐	HQCWF =	HIGH QUALITY COLDWATER FISHERY	☐	DWS	=	DOMESTIC WATER SUPPLY
☐	CWF =	COLDWATER FISHERY	☐	PC	=	PRIMARY CONTACT
☐	MCWF =	MARGINAL COLDWATER FISHERY	☐	IRR	=	IRRIGATION
☐	WWF =	WARMWATER FISHERY	☐	LW	=	LIVESTOCK WATERING
☐	LWWF =	LIMITED WARMWATER FISHERY	☐	WH	=	WILDLIFE HABITAT

Fish culture, secondary contact and municipal and industrial water supply and storage are also designated in particular stream reaches where these uses are actually being realized. However, no numeric standards apply uniquely to these uses.

REACH NAME:

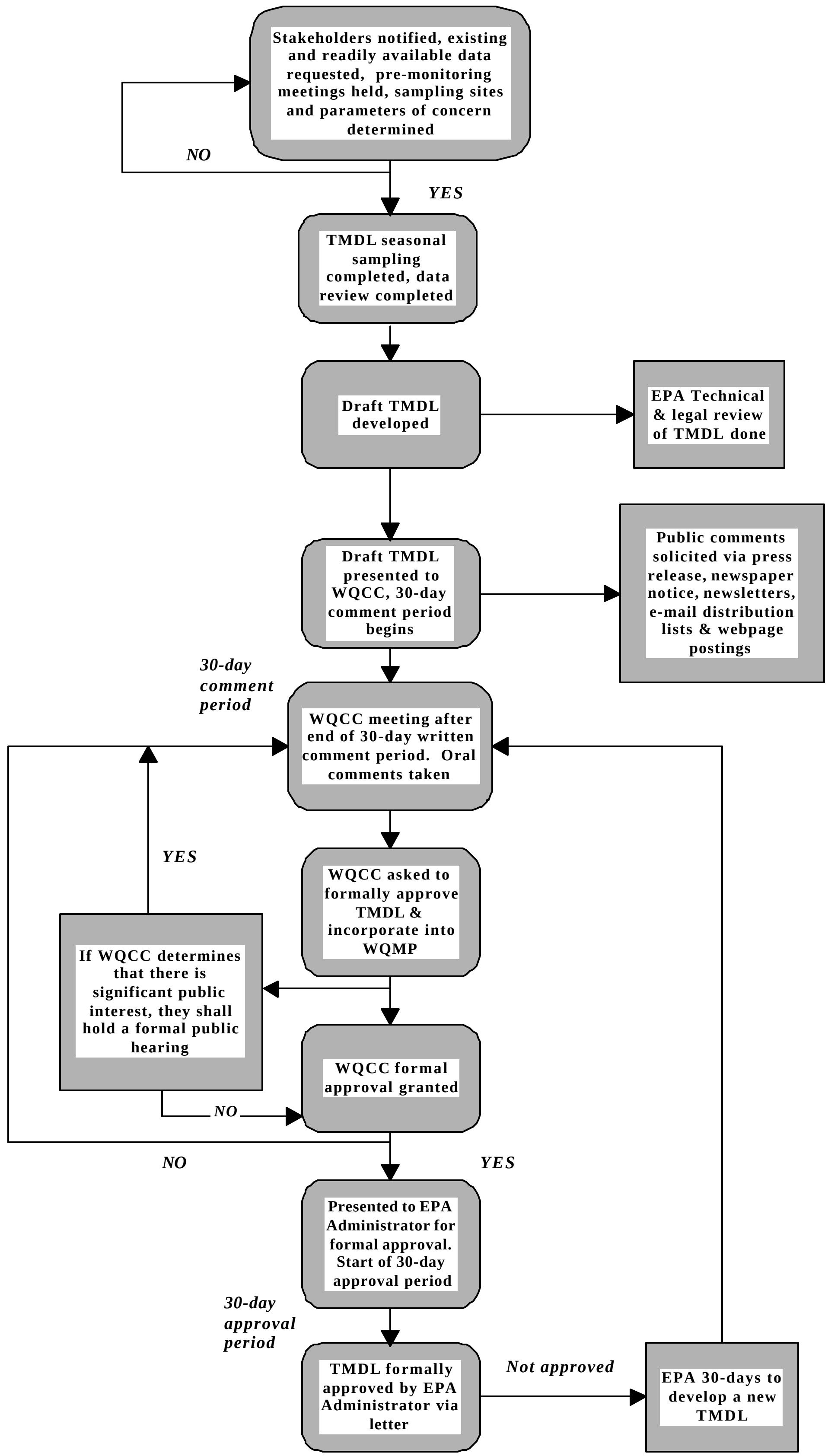
SEGMENT NUMBER:
BASIN:
PARAMETER:

STAFF MAKING ASSESSMENT:
DATE:

CODES FOR SOURCES OF NONSUPPORT (CHECK ALL THAT APPLY)

☐	0100	INDUSTRIAL POINT SOURCES
☐	0200	MUNICIPAL POINT SOURCES
☐	0201	DOMESTIC POINT SOURCES
☐	0400	COMBINED SEWER OVERFLOWS
☐	1000	AGRICULTURE
☐	1100	NONIRRIGATED CROP PRODUCTION
☐	1200	IRRIGATED CROP PRODUCTION
☐	1201	IRRIGATED RETURN FLOWS
☐	1300	SPECIALTY CROP PRODUCTION (e.g., truck farming and orchards)
☐	1400	PASTURELAND
☐	1500	RANGELAND
☐	1600	FEEDLOTS - ALL TYPES
☐	1700	AQUACULTURE
☐	1800	ANIMAL HOLDING/MANAGEMENT AREAS
☐	1900	MANURE LAGOONS
☐	2000	SILVICULTURE
☐	2100	HARVESTING, RESTORATION, RESIDUE MANAGEMENT
☐	2200	FOREST MANAGEMENT
☐	2300	ROAD CONSTRUCTION or MAINTENANCE
☐	3000	CONSTRUCTION
☐	3100	HIGHWAY/ROAD/BRIDGE
☐	3200	LAND DEVELOPMENT
☐	3201	RESORT DEVELOPMENT
☐	3300	HYDROELECTRIC
☐	4000	URBAN RUNOFF/STORM SEWERS
☐	5000	RESOURCES EXTRACTION
☐	5100	SURFACE MINING
☐	5200	SUBSURFACE MINING
☐	5300	PLACER MINING
☐	5400	DREDGE MINING
☐	5500	PETROLEUM ACTIVITIES
☐	5501	PIPELINES
☐	5600	MILL TAILINGS
☐	5700	MINE TAILINGS
☐	5800	ROAD CONSTRUCTION/MAINTENANCE 8400
☐	5900	SPILLS
☐	6000	LAND DISPOSAL
☐	6100	SLUDGE
☐	6200	WASTEWATER
☐	6300	LANDFILLS
☐	6400	INDUSTRIAL LAND TREATMENT
☐	6500	ONSITE WASTEWATER SYSTEMS (septic tanks, etc.)
☐	6600	HAZARDOUS WASTE
☐	6700	SEPTAGE DISPOSAL
☐	6800	UST LEAKS
☐	7000	HYDROMODIFICATION
☐	7100	CHANNELIZATION
☐	7200	DREDGING
☐	7300	DAM CONSTRUCTION/REPAIR
☐	7400	FLOW REGULATION/MODIFICATION
☐	7500	BRIDGE CONSTRUCTION
☐	7600	REMOVAL OF RIPARIAN VEGETATION
☐	7700	STREAMBANK MODIFICATION OR DESTABILIZATION
☐	7800	DRAINING/FILLING OF WETLANDS
☐	8000	OTHER
☐	8010	VECTOR CONTROL ACTIVITIES
☐	8100	ATMOSPHERIC DEPOSITION
☐	8200	WASTE STORAGE/STORAGE TANK LEAKS
☐	8300	ROAD MAINTENANCE or RUNOFF
☐	8400	SPILLS
☐	8500	IN-PLACE CONTAMINANTS
☐	8600	NATURAL
☐	8700	RECREATIONAL ACTIVITIES
☐	8701	ROAD/PARKING LOT RUNOFF
☐	8702	OFF-ROAD VEHICLES
☐	8703	REFUSE DISPOSAL
☐	8704	WILDLIFE IMPACTS
☐	8705	SKI SLOPE RUNOFF
☐	8800	UPSTREAM IMPOUNDMENT
☐	8900	SALT STORAGE SITES
☐	9000	SOURCE UNKNOWN

Appendix H: Public Participation Flowchart



Appendix I: Response to Comments

To be completed later.